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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTION OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

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Furnace and Foundry Glasses.

An interesting question has been raised in our correspondence columns as to chaos which exists in reference to steel-melters' goggles. Briefly, the present position can be summarised by stating that on his initiation into melting practice the novice is advised by the sample passer or melter as to the particular shade of blue he should adopt. The advice generally tendered is that a "correct" melting-down flame should appear through the glasses to be "perfectly" white. Afterwards the whole of his practical experience is based upon the original shade chosen. Some time, sooner or later, and the later the more serious, these glasses are broken. If at this time he is still in the locality, he returns to the shop where he made his original purchase, hoping that the optician still retains a stock of the glass from which his glasses were originally cut. If this can be done, the melter has great good fortune. However, if he has migrated, he usually buys a matched pair, which, if slightly darker, is liable to result in the metal being cast too hot, and *vice versa*. Obviously, a series of really serious commercial losses may result. That summarises the commercial and general aspect, but the medical aspect, as pointed out by Mr. Rhydderch, is of even greater importance. Whilst in the electric arc furnace the presence of actinic rays is of outstanding importance, it should not be lost sight of that they also exist in other types of furnaces, and that blue glass affords no protection whatsoever. The matter is obviously urgent, and is difficult of solution. Mr. Rhydderch has stated that a standard glass exists which is capable of cutting down the glare of the furnace to allow of adequate inspection and control, to protect the eyes from the dangerous infra-red and ultra-violet rays, and to afford protection from flying fragments of solid or liquid metal. If this is so, then every neophyte melter should be provided with such glass *by Home Office Regulation*. As for the experienced melter, pressure should be brought to bear upon him gradually to adopt "standard" glasses, by making daily comparisons with his accustomed shade. Whilst the question is important for open-hearth melters, it is doubly so for the electric arc furnace operator. There are but few who have been continuously engaged in the industry as practical men for more than a decade, and up to now no prominent case has come to light of the occupation having caused total blindness. There have been numerous cases of temporary blindness, however, due to what the men term "arc burn." It is extremely painful, and the average general medical practitioner seems unable to afford any relief beyond keeping the patient in a dark room. We urge that the matter should be taken up now instead of waiting for a "compensation case," which might possibly result in a Royal Commission being appointed, but which certainly *would* result in a certain amount of bad feeling between the litigants and their supporters.

There is another aspect of the subject; that is, the goggles which should be worn by fettlers. Sometimes a flying fragment may attain sufficient impetus to smash an ordinary glass goggle, in which case even added danger may result. This danger can be overcome by utilising the type of glass often utilised for motor car wind screens and made up of three layers stuck together by a transparent gelatinous substance. Such glasses can be made up to physicians' prescriptions which ensures that the fettler not only has mechanically, but also medically correct glasses, which obviously insures better and more work being turned out per unit time.

Marine Engineers Honour Well-known Foundry Chemist.

At a meeting of the Institute of Marine Engineers held last Friday, Vice-Admiral Sir George G. Goodwin, K.C.B., LL.D., presented a special silver medal for the best Paper read before the Institute by a non-member to Mr. H. J. Young, F.I.C., for his lecture on "The Problem of Grey Iron Castings. Mr. Young is chief chemist to the North-Eastern Marine Engineering Company, of Wallsend and Sunderland, and a prominent member of the Institution of British Foundrymen, occupying this year the Branch Presidential chair at Newcastle. In thanking the Institute, Mr. Young remarked that he appreciated the honour not only personally, but as a recognition of the fact that engineers *do* appreciate the chemist when the chemist makes a practical appeal.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Test Bars.

To the Editor of The Foundry Trade Journal.

Sir,—There are several points raised in Mr. Smith's article (Foundry Trade Journal, March 29) on the above subject that are open to criticism. It is now generally accepted that a test bar may not be a true index of the strength of the casting it represents, due to variation in cooling, etc. What the test bar does represent is the quality of the metal used for the casting, and if the bars are made under standard conditions in every case very valuable data can be obtained and comparisons made. We may take it for granted that engineers will always require a test to prove the quality of the metal in their work. That being so, it is up to us to put forward tests that will satisfy them, and at the same time can be reasonably obtained by the foundryman. Mr. Smith puts forward that where castings are water tested, no other test is needed. This looks reasonable, but he forgets that the bedplates, A frames, flywheels, etc., require to be equally strong, and some test is needed

There are two methods advocated by various people. Mr. Smith is wholeheartedly in favour of one size of test bar, with various breaking loads. The American specification is the outstanding example of this. On a 1½ round bar cast vertically in drysand and top poured, they specify for castings in which no section is more than ½ lb., in a breaking load of 2,500 lbs. when tested at 12-in. centres, with a deflection of 0.1 in. For heavy castings, where no section is less than 2 in., a breaking load of 3,300 lbs , with a deflection of 0.1 in. For medium castings, viz., those with sections between ¾ and 1¾ in. thick, a breaking load of 2,900 lbs. with a deflection of 0.1 in. Taking the breaking load of 2,900 lbs. for medium castings; from the work of Prof. Turner and Cook there is little doubt that the strongest transverse test is obtained when the combined carbon is round about 0.7 per cent., varying somewhat according to content of the other constituents. From this one would naturally expect that when the casting and test bar were approximately of the same thickness, the highest test would be obtained under these conditions, especially as there is no difficulty in machining an iron containing 0.7 per cent. CC. Yet the American specification calls for a 14 per cent. increase (viz., 3,300 lbs.) on a 1¼-in. bar for castings, in which no section is less than 2 in. It is evident that either 2,900 lbs. is too low for the medium castings, or that 3,300 lbs. is too high for the thick castings. As I have proved many times, if one casts a 1-in. sq. bar with a mixture suitable for a hydraulic cylinder 3½ in. thick, either a mottled or white bar is obtained, with a decided drop in the breaking load, while on a 2.2-in. bar one not only obtains a grey fracture, but a good tensile or transverse load from the same ladle. A series of tests made yesterday for the Admiralty Inspector will show what I mean. All these bars were cast from the same ladle, the last turned bar being cut from the down runner on the casting.

Size of bar in ins.	Centres. in.	Breaking load in lbs.	Deflection in ins.	Equivalent value for 1 in. sq. × 12 in. centres.
2.17 rd.	18	13,238.4	0.2	3,164
1.2 rd.	18	1,747.2	0.13	2,568
1.0 sq.	12	2,083.2	0.09	2,083
2.2 rd.*	18	10,976.0	0.17	2,623

* Cast 2.5 in. round.

In each case the 1 in. square and the 1.2 in. bars were white in the fracture, while the down gate and the 2.2 in. bar was grey in fracture.

Now if the above evidence is accepted (I can submit at least 20 recent tests bearing this out and tested at places that would preclude any doubt), it would point that instead of an increase in the load on the standard 1¼-in. dia. test piece, it would be necessary to decrease the load to meet castings 2 in. thick and over. If this is done there would be endless disputes between the inspector and foundryman, as to whether the drop in the breaking load was due to the poor metal used or to the increased hardness of the bar due to using a suitable metal for a thick casting. Such a case has come to my notice even in the case of the thin castings, where a batch of ½-in. castings were made and the test bars gave the 2,500 lbs. required, but the castings themselves were as brittle as glass when they came into use, due to poor unsuitable metal.

I, and many others, believe that the size of the test bar should bear some relation to the section of the casting it represents, and it is for this reason three different size bars are advocated to meet the thin, medium and thick castings. Now what are the objections raised. Firstly, Mr. Smith states it would lead to confusion and contention between inspectors and foundrymen. Frankly, I cannot see why. If the casting being made does not in any part exceed ¾ in. thick, the 7-8-in. bar is used. If the casting in hand has no part less than 2 in. thick the 2.2 in. bar is used. For all castings between these the 1.2-in. bar is employed. These thicknesses are there, and can be measured by the moulder, inspector, manager, and are beyond dispute. If one takes a casting with large variations in thickness, such as a turbine casing, the size of the bar would be determined by the mixture aimed at. If the body was 2 in., the flanges 3 in., while some of the brackets were only 1¼ in. thick, it is more than probable one would aim at a mixture to suit the 2 in. body, and trust to the re-annealing of the mass of the casting to soften the 1¼ in. brackets. In that case one would use the 2.2 in. bar. This would be no different from stating which load the bar had to meet with a fixed size bar. No bar will ever approximately meet castings of this sort, and no mixture will give equal strength in very thin and thick parts of the same casting.

We who advocate that the bar should be somewhere about the same section as the costing, do so because the metal would be suitable in each case, and the maximum test could be given in every cast. The load per square inch of area would be less in the large size bar, due to the softer core in the centre, but the casting would also have this same softer core, therefore the bar would represent the casting to that extent.

Another objection raised is that a number of testing machines now in use would not test the new bars. Are we then to sacrifice the castings because of these old type machines? Is this not going further than the engineers, and making the testing machine of more importance than the casting?—Yours, etc.,

J. Shaw

(Chairman I.B.F. Committee on Test Bars).

39, Montgomery Road, Sheffield.

April 8.

Gazette.

A receiving order has been issued in the case of Mr. F. T. Le Duc, 368, Camden Road, N., ironfounder. First meeting, Bankruptcy Court, April 17, at 2.30. Examination, Bankruptcy Court, July 6, at 11.

Mr. D. Russell, trading as D. Russell & Company, Suffolk House, 5, Laurence Pountney Hill, E.C., iron and steel merchant, has been adjudicated bankrupt, an order approving scheme of arrangement dated November 1, 1921, having been annulled.

Trading under the style of the Apex Engineering Company, the partnership between Messrs. A. Kirkland, S. Dawkin, and C. H. Beard, 148, Walnut Street, Leicester, engineers, has been dissolved. Debts by Mr. A. Kirkland, who continues the business as A. Kirkland & Company.

Ironfounders (Bradford Branch) Social Club and Institute.—A petition for the winding up of the company has been lodged by Thompson & Company, 68, Swart Street, Great Horton, Bradford, joiners and contractors. Agents, Halligey & Company, 27, Copthall Avenue, E.C., solicitors.

Trading under the style of Osborne & Graham, Messrs. F. E. Osborne and D. G. Graham, 207, Longley Road, Tooting Junction, precision engineers, have dissolved partnership. Debts by F. E. Osborne, who continues the business.

Granville Brassfoundry Company, Limited.—It has been resolved the company be wound up. Mr. H. E. Carr, 36, Cannon Street, Birmingham, I.A., has been appointed liquidator.

It has been resolved that the Rother Steel and Foundry Company, Limited, be voluntarily wound up. Mr. J. Martin, secretary, has been appointed liquidator.

Facts about Sound Castings, Feeding Heads, Runners and Venting.*

By E. V. Ronceray (Hon. Member Inst. British Foundrymen).

Great interest has been shown in Great Britain in the various papers the author has given in the course of the last two years, referring to the pouring of castings without feeding heads. These papers have been very much discussed, and some experiments have been made in various quarters, either

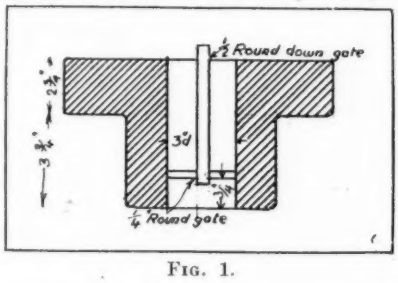

Fig. 1.

for the purpose of proving or disproving the conclusions which have been arrived at. As a matter of fact, no theory or explanation has been put forward, only stated accomplished facts, which, as a rule, seemed to many people to be unexplainable. However, some of the experimenters have succeeded, and some of them have sent the author details of their experiments, while on the other hand, others have failed, and apparently are not in accordance with the author's point of view.

It is now a year since the author delivered his lecture in London, where it was suggested that all foundrymen should try the method for themselves and see whether they could get good results or not by applying the process explained, with the hope that some scientific explanation could be given. The author has continued during this time to work along this line, and is hoping that, whilst he will give freely the knowledge he has gained since the last lecture, some other foundrymen will be in a position to bring some new facts to light.

Some articles appearing in The Foundry Trade Journal, under the signature of "Ecossais,"† mention successful experiments upon the lines indicated in the original lecture and subsequent writings.

Further, amongst the writers who touched on the same subject, though not exactly with the same ideas in view, can be cited Mr. S. G. Smith, who has published quite a number of articles in The Foundry Trade Journal, and Mr. O. Smalley, who has done such very interesting research work along so many lines.

It is perhaps not necessary to come back in detail to the particulars of the castings described in last year's lecture. These have been fully reproduced in the issue of June 1 last of The Foundry Trade Journal.

Before going any further it must be mentioned that some points have come to light, and through them the greater importance than has been originally considered of the proper escape for gases generated in the moulds and clean work in every direction.

In 1920 Mr. Leonard, President of the A.T.F. de Liege, delivered a lecture on the subject of "Blow Holes, Shrinkages and Contraction," to which, perhaps, insufficient attention has been paid. The subject was carried further by him at the 1921 Session of the French Foundry Association in Paris.

Importance of Venting.

The author has gradually come to the conclusion that most of the defects found in castings are due to gases generated in the sand, that have not been able to escape through the sand whilst the metal was in a liquid state, and that have escaped through the metal up to the time of its final freezing.

The slow pouring gives good results, partly because it allows more time for these gases to escape, and that very often the generation of gas has ceased before the metal has attained its solidification point.

The author feels fairly confident that at least for gun-metal castings and for compositions of iron and thickness of castings with which he has been working, there is no need to pay attention to the so-called liquid contraction. This is in strict contradiction to the general belief.

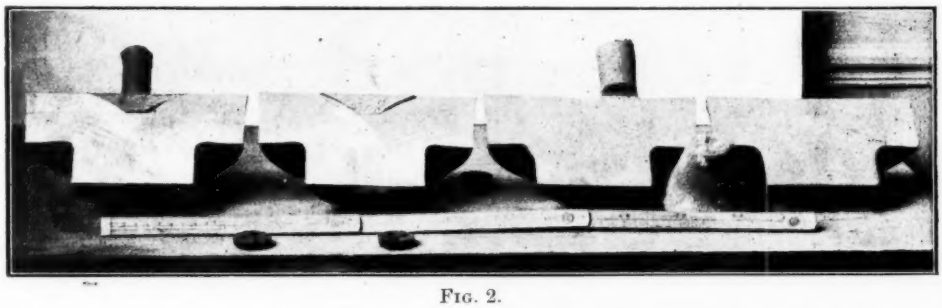

Fig. 2.

Taking, for example, the face-plate coupling successfully made by Mr. L. A. Bentley, of Messrs. John Musgrave & Sons, Limited, Bolton. This was cast by a small runner through the core and imitated a running of a similar casting described in one of the author's papers. (Fig. 1.)

Fig. 3.

In the issue of The Foundry Trade Journal of May 11, 1922, Mr. S. G. Smith refers to shaft couplings which are of the same character. He mentions that: "*These couplings, varying from 3 in. to 6 in., are made with a feeding riser as shown on Fig. 5, and have to be fed from 5 to*

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* A Paper presented to the London and Newcastle Branches of the Institution of British Foundrymen.

† See issue of The Foundry Trade Journal, August 31, 1922.

15 *minutes and still are very often scrapped owing to porosity in the bore.*" *Fig. 6 of Mr. Smith's article shows the method of pouring which is pretty well elaborated.*

The large couplings are moulded, as shown on Fig. 7 of Mr. Smith's article, in dry sand. Mr. Smith mentions that "*these require still longer feeding, say, 30 minutes.*" He finally decided to pour them with solid chill instead of the core, and to bore it out.

In the issue of The Foundry Trade Journal dated August 17, 1922, Mr. S. G. Smith says: "*The writer has not tried the small centre runners in shaft couplings, which vary in weight from a few pounds to twelve cwts. If the small runner contributes to make these castings clean, sound and free from porosity without chills or feedings, much has been accomplished.*"

Although the possibility of getting a sound casting of this character seems to have been amply proved by Mr. L. A. Bentley's experiments, the author decided to pour a few castings for his own satisfaction.

Fig. 2 refers to a group of couplings about the size mentioned in the first case by Mr. S. G. Smith. They are poured through a simple runner about 1 in. to 1¼ in. dia., with a filter core as shown in the photograph. No riser was used, and of course no feeding was resorted to. Sound castings were repeatedly made as the result. The illustration shows some of them sectioned up, and as it might have been suggested that they could have been unsound just below the runner, one was split just at this point showing a very sound casting.

A much larger coupling, shown on Fig. 3, was made and split afterwards. The section is of the utmost interest—the left side is perfectly sound, whilst the right side shows porosity. It might be thought that this is due to common shrinkage, always feared by foundrymen. However, on careful examination, it can be seen that the porosity communicates with the central core. It has, without any doubt, been produced by the escape of the gases generated in the core through the metal. For some reason this gas could not escape entirely through the venting hole of the core, and thus it escaped by blowing through the metal.

This is one of the effects so well described by Mr. Leonard, and shows exactly the amount of special care which must be taken to provide for the escape of gases wherever they are generated in large quantities of sand surrounded by masses of metal. This explains why a runner through the core is no longer used, the author's experience being that it adds to the risk of blowing, the core being heated inside and outside. The perfect soundness of the left-hand side of the casting (Fig. 3) and the soundness of the right-hand side, with the exception of the parts submitted to the gas action, is a very interesting demonstration of exactly what usually happens in moulds which have been considered hitherto as shrunk castings.

Also, in the issue of August 17, of The Foundry Trade Journal, Mr. S. G. Smith refers to castings described by him in the issue of May 18 of the same year.

It is Mr. Smith's Fig. 2 which is more striking than the others, which are simpler ones. Mr. S. G. Smith mentions that: "*With normal methods of moulding, there is nothing to prevent the thick section of iron marked 'A' being free from porosity and draws.*" He says that: "*The heavy part has been tried cast-down, but drawn places in the heavy section were so bad that it was not repeated.*"

The method he adopted is shown in his Fig. 5. A head of 1¾ in. thick and 4 in. deep was carried round the top of the heavy section. Underneath the heavy section a circle of chills are placed leaving only a minimum allowance for machining, and

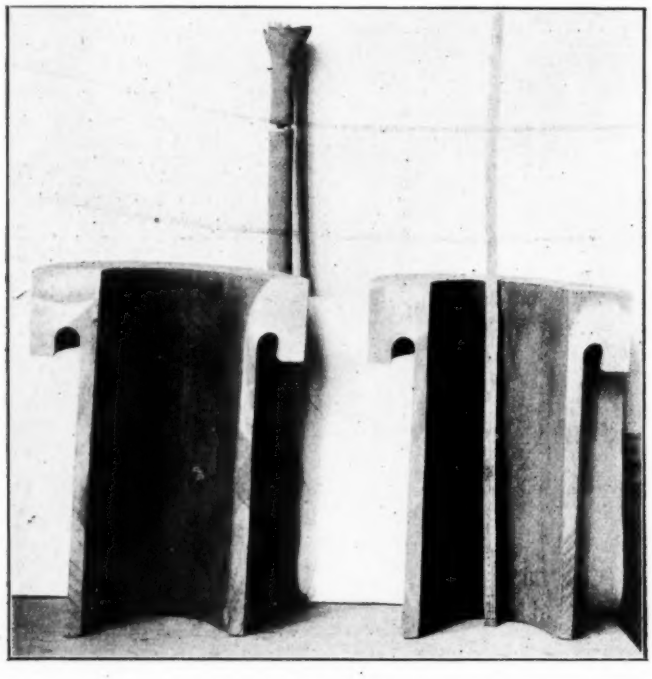


Fig. 4.

the castings were, in addition, slightly fed by rods. The runner gates pass down the middle of the centre core and branch off in two directions.

Mr. Smith also says, in the issue of The Foundry Trade Journal of August 17: "*Fig. 2,* Foundry Trade Journal *of May 18, page 366, shows small centre runners through the centre core similar to those of Mr. Ronceray, but these castings could not be produced perfectly sound and clean without the application of denseners and dross head.*" In passing the author repeats what he said previously of the centre runner and also that he used it to avoid a check. The side runner would give same or better results.

He was convinced from his previous experiments that the porosity was not due to shrinkage of metal, but to the escape through the metal of gases produced in large quantities in the narrow space "A" superheated by the heavy surrounding masses of metal. It is supposed that the production of gases was so considerable that they could not escape through the imperfectly vented mould.

The author simply made a core, which, by the way, was constructed of "Phixine" to produce the shape "A." This core was especially well-vented up to the edge of its top. A groove was made at the bottom. The outside of the pattern was made exactly as the casting and laid upside down on a

board. The core was then set into place and the groove filled in with small coke. Sand was rammed around, and some large vent-holes were made connecting with the coke groove. The pouring was made at the thinnest part, the heavy part of the casting to the top part of the mould. The runner was of indifferent size, but a filter core was placed on the mouth. A good head of about 7 in. of metal was provided.

The section of the casting (Fig. 4) shows very sound metal. Its weight is 135 lbs.

A third example mentioned by Mr. S. G. Smith refers to intermediate cylinder heads in vertical gas engines shown in The Foundry Trade Journal, issue, July 6, which says, "*It is a problem that could not be solved by small runners.*"

From what has been said above, it is perfectly apparent that the trouble has arisen from the

Fig. 5.

same cause, that is, insufficient provision for escape of gases in narrow thicknesses of sand superheated by a good thickness of metal around it. It would have been too costly to make a special pattern for the simple purpose of experimenting, but the author considers that there is no doubt at all that his opinion is correct in this direction. On the other hand, if Mr. Smith will himself try by setting a venting tube through the core and providing for the easy escape of gases produced whilst pouring, good results are certain.

Most of the cases mentioned by Mr. S. G. Smith in his articles are nearly all identical, and can be cured by the same means. The author consider the spreading of this information as a most promising move. Mr. Smith deserves the thanks of the industry for bringing forward these points which really provide intelligent discussion and research which is all to the benefit of the foundry trade in general. No personal invention is claimed, as the only action has been the careful study of Mr. Leonard's Papers and the putting of his theories into actual practice.

Mons. Leonard's Experiments.

It may just be as well to describe one of the typical Leonard's experiments. He made an oval conical cup, at the bottom of the inside of which there is a round boss, leaving only a very narrow space between the boss and the cup on the small side of the oval and a much larger one on the long side. In ramming a mould in the usual way

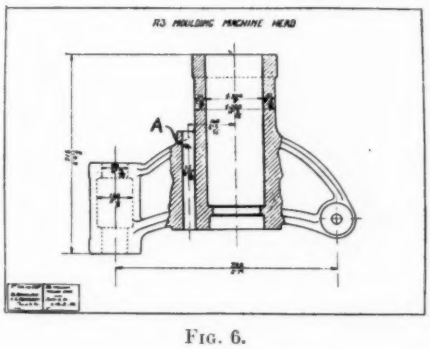


Fig. 6.

and after pouring it, porosity was invariably shown in the narrow space while nothing of that description occurred on the large side.

The action of the gases is rendered evident by this small experiment.

Fig. 5 shows a casting as a crude bearing for trucks. The drawn portion was cast below, and, as may be seen, this portion is where the sand is most heated.

No. 1 shows a very common effect, and this one the author has called the "Leonard effect." No. 2 is a section of a casting having the same defect. No. 3 shows the casting where the inside sand fell away and which is perfectly sound. The trouble was cured by more careful ramming and changing the sand for one of a more permeable character.

On the other hand it must be remembered that when making automobile cylinders the porosity invariably shows at the junction of two barrels;

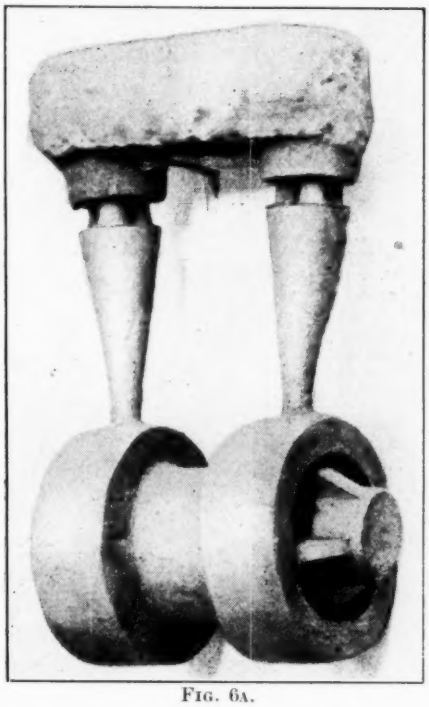


Fig. 6a.

it is generally attributed to an increase of thickness at this particular place, but a curious fact is that at other places like flanges or bosses, where the metal is much thicker than at the junction of two barrels, no draw takes place. As a matter of fact, it is not due to thickness of metal at that particular point, but to the congested sand heated on several sides with improper venting. The author has, on many occasions, been consulted about the reasons of draws on automobiles pistons. Generally speaking, the inside has two bosses which are united to the cylindrical part by a very thin rib. A draw is very frequent at this junction of

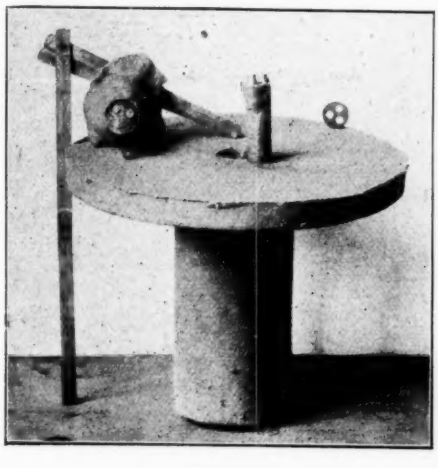


Fig. 7.

the rib with the boss or the barrel. It is a ridiculous statement, though it has been often made, to attribute the draw to thickness of metal. As a matter of fact, it is exactly the same case as before, the gas cannot escape quickly enough through the sand, and consequently it escapes through the metal leaving a trace of its passage. In doing away with the ribs and filleting the junction of the boss of the barrel, the trouble is generally cured.

An interesting case which proves that thicknesses of metal have very seldom anything to do with porosity, whilst, on the other hand, insufficient venting is very often the cause of the trouble is that of the cross beams of the Bonvillain R.3 moulding machine which were for a long time made by an outside foundry and were machined in the author's shops. On machining, these cross beams invariably showed a porosity at the point "A," Fig. 6. The works manager, having no knowledge of foundry matters, finally decided to drill the hole and to have this particular spot cast solid in the foundry. This was quite satisfactory, but when we came to make the castings in our own foundry it was apparent that it was not satisfactory to have such a heavy mass of metal, and, consequently, the patterns were altered so as to core it out. Porosities immediately appeared again. No special attention was paid to this fact, but to cure the trouble the author decided to use a chill, and, consequently, we inserted instead of the core a heavy tube, tinned on the outside. Good results were obtained, but when the phenomenon explained above was fully understood it occurred to the author that, if the core was well vented, the chill could be avoided; consequently a core was made with a venting split tube inside, and special care taken to provide for the gas escape. Porosities have entirely disappeared, and now, of course, the expense of the chilling tube is saved.

In a valve-body which gave trouble to Mr. F. Wilson, of Messrs. Pease & Partners, very probably the difficulty was due to the congested part of the sand between the rim and the boss. After a visit to the author's works, Mr. Wilson has made experiments and, whilst he could not get good results before, he now succeeds in every case. (Fig. 6a.)

Fig. 7 shows a representative example of the author's daily practice. A simple down-gate, covered with a filter core at the bottom of the cup. The head, which is 3 in., could be increased with advantage. The weight of the casting is 160 lbs.

Fig. 8 shows a very good example of what are often considered as draws, but which are not draws. The pouring has been made approximately in the same manner as previously. On the left hand side it is very apparent that the draw has come from an insufficiently-vented core. The right hand side shows a most interesting case. In this side it may be seen that there is a pin showing communication between the main hole and the small one on the top. The place where the small hole appears shows a slag inclusion. This slag stuck on the top of the mould and solidified at the contact point with the sand, making a sort of enamel. The bottom part, which was in contact with the metal, reacted with it, producing gas which escaped below, the enamel not allowing it to escape above, and, of course, the gases went direct to the runner. Superficial observation would have concluded that there was a draw in the casting; however, it was the only one showing this defect out of perhaps 50 castings made on the same day.

Mr. Smalley's Researches.

Mr. O. Smalley, the distinguished metallurgist of the Gateshead Works of Messrs. Armstrong, Whitworth & Co., Ltd., who has written in the past so many valuable papers, has now given a most interesting one quite recently before the Newcastle Branch of the I.B.F.

He has kindly referred to the author's work, and he has seen with pleasure that we are in accordance on many points, one of which is that we know very little about the scientific principles of liquid shrinkage, and another is what happens in a mould. We are also in agreement with the possibility of casting in grey iron without drawing under certain conditions. However, after making some experiments, the author cannot confirm some points, probably on account of the difference in training for the profession.

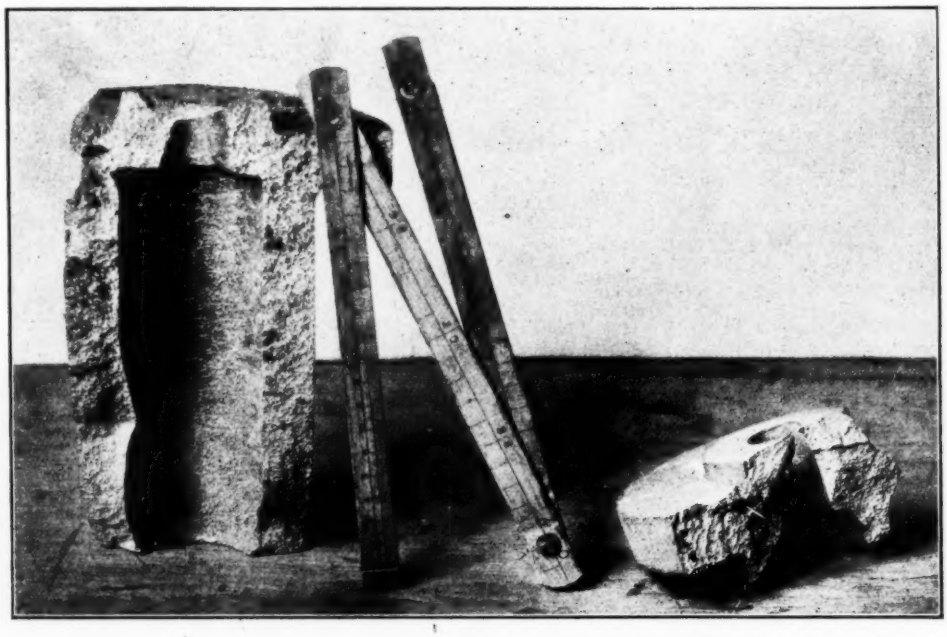


Fig. 8.

Mr. O. Smalley is a distinguished metallurgist, whilst the author is only a modest foundryman, not having even, at the present time, the benefit of a laboratory. He hopes in the near future to be able to install one. The author's experiments and remarks consequently are only those of a practical man, and if some benefit comes out of them it will show once more that the motto of the Institution of British Foundrymen, "Science hand in hand with Labour," is a very good one.

Starting with the discs which Mr. O. Smalley cast at different temperatures, it occurred to the author, from the sulphur prints, that air has been entrained in the runner producing SO_2 in the casting by which the author called the "Custer effect." Custer has demonstrated that when air is entrained with iron blowholes are often found. He made experiments with sand and iron moulds, thus eliminating the sand action or "Leonard" effect, and showed very conclusive results.

The author has made the same experiment, but he put several discs in the same mould along a long runner, the mould being slightly inclined so that the furthest discs could not be filled before the nearest ones. The runner had a filter core and the cup was maintained full. By this arrangement the first disc was poured with very hot metal, whilst the last one was poured with very cold metal, but in every case there was no entrained air. The castings were all perfectly

sound. It can thus be seen that the action of the low temperature alone is not sufficient to produce a blown casting, but that the mixing of cold metal with air is prominent.

The same effect can be found elsewhere in Mr. O. Smalley's Paper, and hinders somewhat the true action of cold metal.

To verify the opinion obtained through previous experiments, Mr. O. Smalley selected some shapes of castings.* Mr. Smalley's casting "A" requires no comment, but "B" is a flange pipe. "*With soft grey iron*," says Mr. Smalley, "*a draw was observed all round the flange, and to obviate this chills were used with success. A harder iron gave a good casting without chills or risers.*" It should be observed that for a pipe cast horizontally a

Fig. 9.

draw due to shrinkage cannot exist at the bottom as well as at the top. The defect was no doubt due to a gas action, and one of the above experiments made with a 3.5 per cent. silicon iron on a commutator bush casting mentioned by Mr. S. G. Smith proves that there is no draw under a very heavy flange in a well-vented mould.

No doubt there is a similar action for the brake blocks "C" and the stuffing box "D." In this last case the porosity in the bore is similar to the coupling shown before.

To make his experiments on the effect of various compositions of cast iron on shrinkage, Mr. O. Smalley selected the special section shown, Fig. 36 of his Paper.† In the opinion of the author, it is a very good example of a casting difficult to vent in a proper manner. It will easily be recognised that the same causes of porosity have been described earlier. There is a thin part of sand surrounded by heavy masses of metal, which heat the congested sand terribly. However, in using a core well vented in the narrow section. the author has succeeded in making several of them perfectly sound by using ordinary very grey common iron having about 3.5 per cent. silicon. It was cast in every position with the same success.

Fig. 10.

Further experiments were made, and in one casting the narrow opening was eliminated, which in consequence made the casting thicker, which must have resulted in a draw. The casting was quite sound, as shown in Fig. 11.

A waster was also made (Fig. 12). Only a little hole can be seen. It was split through the mortise, and it can be seen very well that the trouble came from the core and not from the shrinkage of metal. The little hole is only the end of a considerable porous place which communicates with the thin core.

Cubes have been made by Mr. O. Smalley to determine the kind of irons which were most convenient to get a sound casting. The conclusions are that it is easier to get this result with low silicon irons, cooled quickly. It sounds reasonable, and certainly is in the right direction.

A cube looks quite a simple casting to make. As a matter of fact, it is one of the most difficult to make sound. It was mentioned in the previous lecture that the author did not know how to make all castings and that he had not yet succeeded in making a good size "Jet," *i.e.*, a piece of cylindrical cast iron. One day the author's foreman, whom he kept trying unceasingly, had an idea to ram in each "jet" pattern a venting rod of large section, which was taken off when the moulding was finished; and also the foreman had an idea to pour with a good high head. Nearly all the "jets" were sound. The author thought once more of what he calls the "Leonard" effect. There were no sharp corners in such castings, but the gases generated between two heavy "jets" had no short escape to the atmosphere. The moulding box was an air-tight envelope, and to go to the top or bottom of the mould made a long distance for the air to travel through the sand. Thus the gases had to escape, to a great extent, through the metal up to the moment of final solidification, leaving a hole in the casting.

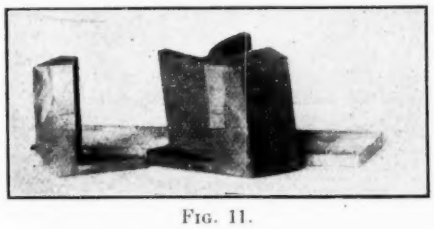


Fig. 11.

Exactly the same thing happens with a cube. The mass of metal is heavy, and the amount of gas produced is enormous. The simplicity of the casting does not suggest special venting precautions, so that what happens is bubbling through the metal with resulting porosity. In venting properly and by using sufficient head of metal almost sound cubes have been obtained, but so far perfect ones have not been made.

It was thought that the gas action could be practically eliminated in the following way:—Bull ladles were taken, and into them were drilled quite a number of holes. They were daubed with the ordinary cupola daubing and dried carefully. They were filled with cast iron through a filter core to avoid slag. The cup was taken off the bull ladle before being empty, so that no slag could get into it. The size of such ladles was quite comparable with Mr. Smalley's cubes. By this method several sound blocks of iron are shown. The hotter the metal the sounder it appeared to be. Some of these blocks were not sound, and it was very apparent that when such was the case a small crust was found just above the porosity, which suggested

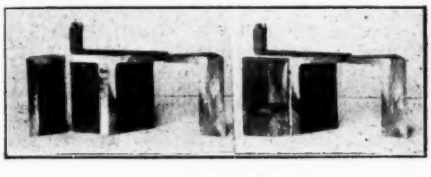


Fig. 12.

that a little slag was produced in the ladle or in the cup which remained on the top of the metal.

It is proposed to make more elaborate experiments with a similar mould with a sand top and bottom pouring, so as to eliminate the chances of having this small amount of slag on the top. A slice of this block was quite sound. The actual liquid contraction is certainly very small, if there is any. The centre of the mass is coarser, but there was no definite hole there.

It would be just the same with sluice valves and the bed-plates mentioned by Mr. Smalley. In this case gas from the sharp corners of sand heated by large masses of metal bubbles into the liquid metal. This action is eliminated by using chills, but chills are not indispensable. The action of chills is to avoid gas going into the liquid metal, and perhaps, to a certain extent, to increase the speed of cooling, which, there is no doubt, closes the grain of the metal.

It is certainly through a misunderstanding that Mr. Smalley mentions that the author suggested exclusively bottom pouring, as in the issue of The Foundry Trade Journal of June 1, 1922, examples of top pouring are shown. It is a question simply of deciding in each case, and depends more on practical conditions than on theoretical ones.

* See The Foundry Trade Journal, page 92, issue Feb. 1, 1923.
† See The Foundry Trade Journal, issue Feb. 1, 1923, Fig. 36.

Mr. Smalley considers that excessively hot metal means increased cost, and "is not practical in a large jobbing foundry." The author is of opinion that such a metal is a "blessing" in any foundry, and it is easy to obtain when the cupola is properly handled. The cupola is not the rough apparatus that is usually described. It is a marvellous tool in good hands. The extra coke required to get extra hot iron does not amount to much, say 2 per cent. of coke or 1s. 2d. per cwt. of iron. If in the cupola the siphon brick is used, a 20-lb. ladle can be taken from the cupola, as well as 5 tons.

The result of the author's experience since last year may be summed up as follows:—

(1) Melt very hot, and pour hot through filter cores placed at the outlet cup.

(2) If the casting is heavy, use two, three or more filter cores in the same basin.

(3) A refinement to avoid the slightest drop of slag entering the mould is to put on each filter core a paper disc, which burns away when the first drop of metal has reached it.

(4) Use a good head between the filter core and the top of the casting (6 to 8 in.) in order to force the gas to escape through the sand.

(5) Good permeable sand must be used.

(6) Venting must not be made indiscriminately, but where bodies of sand are surrounded by heavy masses of metal, special care must be taken for venting.

Such methods are now in daily use in the author's small foundry, where we make practically all our castings without feeding heads or risers. We have no castings weighing more than 2 tons, but most of these are tested to 1,500 lbs. water pressure per sq. in. The author would be only too glad to receive a visit from all interested foundrymen of Great Britain or from any other country. He sincerely hopes that a good many of you will consider the opportunity of the coming International Congress and Exhibition to be held in Paris at the Ecole des Arts and Métiers from September 6 to September 20, not only with a view to seeing the Exhibition, which is sure to be very interesting to all foundrymen, but to investigate any points of this Paper which may need confirmation.

Iron and Steel Institute.

Annual Meeting, 1923.

The annual meeting will be held, by kind permission of the Council of the Institution of Civil Engineers, at Great George Street, Westminster, on Thursday and Friday, May 10 and 11, 1923, commencing each day at 10 a.m. and 2.30 p.m.

Thursday, May 10.

General meeting of members at 10 a.m. The Council will present their report for the year 1922, and the hon. treasurer the statement of accounts for 1922. Scrutineers will be appointed for the examination of voting papers. Election of Council. Presentation of the Bessemer medal to Dr. W. H. Maw.

A resolution, formal notice of which was given at the autumn meeting, on September 5, 1922, of the alteration of by-law 10, relating to the election of the President, will be submitted. The terms of the present by-law are as follows:—"The President shall be elected for two years, and shall not be eligible for re-election until after an interval." The terms of the resolution are:—"That the by-law shall be altered as follows: 'The President shall be elected for one year,' and to omit the words, 'and shall not be eligible for re-election until after an interval.'"

Papers Nos. (22), (6), (10), (24), (18) and (15) will be read and discussed. At the afternoon session, at 2.30, Papers Nos. (5), (2), (11), (20), (23) and (24) will be read and discussed.

Friday, May 11.

General meeting of members at 10 a.m. The award of the Andrew Carnegie Research Scholarship for 1923 will be announced, and Papers Nos. (1), (7), (8), (13), (17), and (12) will be read and discussed. At the afternoon session, at 2.30, Papers Nos. (9), (16), (21), (14), (3), and (19) will be read and discussed.

List of Papers.

The following is a list of the Papers which it is expected will be submitted at the meeting:—

(1) "Economic Principles governing the use of Electrical Power in Iron and Steel Works," by C. A. Ablett.

(2) "On the co-relation of the Chemical Constitutions of 'True Steels' to their Micrographic Structures," by J. O. Arnold, F.R.S.

(3) "Some Mechanical Properties of a series of Chromium Steels," by C. R. Austin.

(4) "Some Experiments on Grain-growth in Iron and Steel," by L. E. Benson and F. C. Thompson.

(5) "The Production of Single Metallic Crystals and some of their properties," by H. C. H. Carpenter, F.R.S.

(6) "British Steel Works Gas-Producer Practice," by F. Clements.

(7) "The Constitution of Basic Slags—its relation to Furnace Reactions," by T. P. Colclough.

(8) "Some Properties of Steels containing Globular Cementite," by C. H. Desch and A. T. Roberts.

(9) "A Contribution to the Study of Hardness," by C. A. Edwards and C. R. Austin.

(10) "Some Characteristics of Moulding Sands and their Graphical Representation," by J. E. Fletcher.

(11) "The Constitution of the Alloys of Iron and Steel," by D. Hanson and J. R. Freeman.

(12) "Note on a Value for the Surface Tension of Iron Sulphide, by E. J. L. Holman.

(13) "The Structural Constitution of Iron-Carbon-Silicon Alloys," by K. Honda and T. Murakami.

(14) "The Ac I. Range in Alloy Steels," by J. J. A. Jones.

(15) "Change of Density of Iron due to Overstrain," by J. W. Landon.

(16) "An Investigation of the behaviour of certain Steels under Impact at different Temperatures." by F. C. Langenberg.

(17) "Some Investigations on the Quenching of Carbon Steels," by T. Matsushita.

(18) "A Note on Temper Carbon," by L. Northcott.

(19) "Variation of Brinell Hardness Number with Testing Load," by H. O'Neill.

(20) "The Potential Energy of Cold-Worked Steel," by T. F. Russell.

(21) "The Cold Working of Steel with reference to the Tensile Test," by J. Stead.

(22) "The Reactivity of Coke as a factor in the Fuel Economy of the Blast Furnace," by E. R. Sutcliffe and E. C. Evans.

(23) "The Changes in Iron and Steel below 400 deg. C.," by F. C. Thompson and A. Goffey.

(24) "Some Observations on the effect of small quantities of Tin in Steel," by J. H. Whiteley and A. Braithwaite.

Annual Dinner.

The annual dinner will be held in the Grand Hall of the Connaught Rooms, Great Queen Street, London, W.C., on Thursday, May 10, at 7 for 7.30 p.m. Applications for tickets (price 15s. each) should be made not later than Saturday, May 5.

Autumn Meeting in Italy.

As already announced, the autumn meeting will be held in Milan, by kind invitation of the Italian Metallurgical Association, and will be followed by visits to the chief industrial centres in Italy. The approximate cost of the journey from London to Italy and back, of the tour in Italy, and of all hotel and of other incidental expenses, is 50 guineas, and from other points of departure (Paris or Milan) will be proportionately lower. Members who have not already returned the reply forms relating to the autumn meeting, which were posted to them on January 22 last, and who anticipate being able, so far as their present arrangements allow, to participate in this meeting, are earnestly requested to send in their reply forms as soon as possible. The final particulars and detailed circular will be sent out only to those members who have signified their intention of availing themselves of the arrangements made.

Some Failures in Malleable Castings.*

By F. H. Hurren, A.I.C., M.I.Brit.F.

In these days of progress and keen competition, where no avenue which may lead to economical production should remain unexplored, rule-of-thumb is being compelled by force of circumstances to give place to scientific control. Foundry work is such, however, that we are not able to eliminate the human element, and as to err is human, we are liable to failure.

It has not been the custom of foundrymen to talk of their failures, but it will be generally admitted that much knowledge is to be obtained from the examination of "wasters," and it is with the object of fostering this idea that some failures in malleable castings which have come before the author during the past few years are introduced.

Time Losses in Experimenting in the Author's Firm.

In the ordinary course of business the author's firm produces between 12,000 and 14,000 amlleable castings per week, and as this is not the age of miracles, some failures are inevitable. From experience it can be stated that malleable troubles are the most tedious and most disheartening investigations to undertake. Under even the best conditions, practically a fortnight must elapse between the time that trouble develops, and castings made under different conditions can be tried out in the machine shop.

Should the fault not be remedied at the first attempt, another fortnight must pass whilst further efforts are being made. During this time production of the particular casting is suspended entirely, or, should the need be urgent, is continued in the faint hope that some good castings may be obtained.

One might ask, why should faulty castings result if standard practice is followed? Cases have been known where, after several hundred castings have been made successfully, a bad patch is struck, and although the same process is followed, apparently in every detail exactly as before, the percentage of scrap mounts up alarmingly. Consider, but for a moment, the processes followed in the manufacture of a malleable casting, and the variables that are likely to be present.

Possible Variations.

In the first place the mould is rammed-up from a plate. Variations are possible in the composition of the facing sand, coal dust, etc., the degree of hardness to which the sand is rammed, the venting, or absence of venting, amount of moisture in the sand, and last, but not least, the degree of skill of the moulder. The same remarks apply in the production of the cores. Pig-iron, a variant of infinite possibilities, and scrap, another uncertain quantity, is melted by coke, which may vary from day to day. In the cupola there can be variations in the blast pressure and volume, in the method of charging, in tapping-out, with the possibility of "bridging" upsetting the mixture. Infinite variations can be made in the method of pouring, in casting temperature, and in rate of cooling. Assume then that by some freak of fortune there has been produced a casting which appears sound. After rough fettling it is packed in an annealing pan with a mixture of red and black ore, the composition of which may cover a wide range. There are numerous choices of position in a particular stack of pans, and, with a large annealing oven, numerous choices of position for that stack. The oven is then coal- or gas-fired, and the possible variations in the method of firing, rate of heating-up, temperature of annealing, time of annealing, rate of cooling, and temperature at which the oven is opened, are legion. Can it be wondered at that some failures result? Is it not more marvellous that good castings can be produced in quantity?

Works Control.

In the author's practice, he takes all possible precautions to avoid failures. Samples from each truck of pig-iron are analysed for silicon content, each truck load being stacked separately, labelled with the truck number and analysis. Frequent analyses are taken of the coke supplies. All charges are weighed on the cupola stage, and during the cast three samples of iron are taken for silicon content. The first sample is taken from the second tap, and the result is known within an hour. A second sample is taken half-way through the cast, and the result of this is known an hour later. A third sample is taken just before the end, and the silicon content known the next morning. Should the analysis of the first sample not reach expectations, an alteration can be made in the subsequent charges. Having three analyses each day enables the scrap, runners and feeders to be sorted for use on some later date. The castings are packed in the annealing furnace in such a manner that the heavier castings are in the position likely to get most heat. The Rover Company have two gas-fired annealing furnaces of approximately 8 tons capacity each, and a number of small coal-fired furnaces of capacity ranging from 35 to 70 cwts. In each of the larger furnaces there are four thermo-electric couples, one in each wall, connected up to double-thread recorders. Thus a continuous record of the temperatures in four different places in each oven is available. The smaller furnaces have one couple fitted in the back wall, each pyrometer being connected, through a switchboard, to a double recorder. This allows of twelve continuous records to be taken at any time. Every care is taken in firing, and a minimum time allowance at annealing temperature is set. After the furnace is opened out, samples are taken for testing. The general practice of the Rover works is to make a rough test by hammering and bending, occasionally a proper tensile test, and from each furnace a representative sample is taken for analysis. In cases of doubt, the analysis is supplemented by microscopical examination. In spite of these precautions the product is not free from failures, and it is often difficult to assign a reason.

Metallurgical Failures.

It is proposed to deal mainly with failures caused by defects in metallurgical and manipulative processes, as distinct from castings discovered scrap through faulty moulding practice.

Contraction is one of the most formidable difficulties in malleable production. Castings will crack through resistance to contraction set up by a hard core, and this is a more prolific cause of waste than many would credit. With some castings, as soon as they are set, it is necessary to remove them from the sand to a hot muffle, for slow cooling. When taken out of the muffle it is not uncommon to find a crack, or series of cracks, in the casting varying from $\frac{1}{8}$ in. to several in length. Much of this waste can be avoided by making the cores more collapsible, and also by digging out the core before the casting is placed in the muffle. It is common knowledge that the moulder always blames the coremaker for a waste casting, and in many instances the complaint is justified. It is easier for the coremaker to make a nice-looking, but hard, core than a "rotten" core: and it is also easier for the moulder to place hard cores; but the forces exerted by contraction are so great, that either the sand has to give way or the casting to crack.

Variations in the composition of the iron are another factor to be considered in connection with cracking. It is a well-known fact that the lower the silicon content, the greater the contraction: and if the mixture has changed from, say, 0.8 to 0.45 per cent. Si, extra precautions must be taken to guard against danger from contraction.

Skin Defects.

Cracks in the "skin" of the casting, more commonly known as sears, are another source of trouble. These usually occur at a sharp edge, or at a junction of a thick and thin section, and often the only remedy for this complaint is to increase the radius in the pattern.

* A Paper presented to the Birmingham Branch of the Institution of British Foundrymen, Mr. W. J. Flavell presiding.

Draws.

Liquid shrinkage is another important factor to be considered, and many an otherwise-good malleable casting is spoiled by a "draw" in a thick section. In some instances this is not discovered until the casting has been part-machined. As a general rule this is a moulding problem, and one that can be solved by the proper placing of chills or feeders. In connection with this trouble, it may be of interest to note an interesting case which has cropped up recently, an axle-case which is machine-moulded, all runners and feeders being on the pattern plate. This casting has been made successfully for over three years, during which time several thousands have been made. Quite recently, porosity developed in one end of the worm case, where it is essential the material should be sound. The trouble consisted of a dark, spongy patch about the size of a shilling, and always by the side of one particular boss on the casting. The difficulty has been temporarily overcome by placing a feeder close to the affected spot, but it seems incomprehensible that so many castings could be made without this fault. The author's theory is that owing to the pig-iron supplies running higher in total carbon than before, there has been a segregation of carbon in one particular part, and this excess carbon has caused the sponginess. If the theory of inherent properties holds good, variations in blast furnace practice give certain properties to the iron which persist in remelting.

Inherent Properties.

Whilst on this subject, it may be interesting to ventilate an idea held by the outhor for some little time, and on which he is open to correction or criticism. Malleable pig, as supplied by the makers, is usually in two sizes, one a medium pig, and the other a small pig, generally called "refined" iron. From a careful study of the working of both kinds of pig, it was found that troubles in connection with cracking, drawing, and sponginess, are always greater when using medium pig than when using refined iron. It may be coincidence, as at present there is apparently no scientific reason, but the author is so convinced that in his own works he has decided to use refined iron only.

Fragile Castings.

A malleable casting must be soft, ductile, and show good results on testing for tensile, elongation, and angle of bend. Unless it has these properties it must be considered a failure. Although soft for machining, some castings have little or no ductility; others will show only a small bending angle before cracking. In the first category, there are castings which machine easily and take a good finish, yet will fracture at a slight blow. A visual examination of the fracture usually shows a thin decarburised edge varying up to 1/16 in. deep, with a coarsely crystalline centre. The explanation of this may be analogous with that of "peeling." During the early stages of annealing, owing to irregular working of the furnace, the castings become subjected to a strongly oxidising atmosphere, whilst at a high temperature. Surface decarburisation takes place, slowing down the action of the annealing ore, and prevents the elimination of the carbon from the main section of the casting. During cooling, the decarburised edge remains unchanged, whilst beneath it is a material containing both combined and annealing carbon. If a section showing this type of fracture be polished, etched, and examined under the microscope, three distinct areas can be seen. The outer edge is practically pure ferrite, then there is a section showing pearlite, beneath which is the main portion showing ferrite, pearlite, and annealing carbon. Unfortunately this type of failure can only be discovered by actual breakage of the casting, and every care should be taken in the manner of packing in the annealing furnace, and in the method of firing, to avoid the risk of oxidation, otherwise serious consequences may result.

A somewhat similar occurrence takes place in those castings which are soft, but will not bend many degrees before cracking. It will usually be found that a casting which exhibits this trait, has been exposed during the annealing process to an oxidising atmosphere, more often than not to a direct exposure. Owing to a defect in packing, or in luting up the joints of the annealing pans, a casting has become fully exposed to the gases in the furnace. The surface of the casting is generally more or less scaled, and it is by this scaling and pitting that this type of failure is recognised before it can get into service.

Hard Spots from Grinding.

Hard patches in castings occur from time to time, usually where a runner or feeder has been ground off in the fettling shop. Generally speaking, where such hard patches occur, the casting has not been thoroughly annealed right through, and grinding removes most of the annealed surface, exposing the harder material. The only remedy for this type of trouble is to increase the time or temperature of annealing. Instances have been found, however, of castings being perfectly soft everywhere except where it has been fettled, and in most of these cases the total carbon in the finished casting has been fairly high, somewhere in the neighbourhood of 3 per cent. The author is of the opinion that the heat generated during grinding causes some of the carbon to re-combine with the iron, and remains as cementite on cooling. Castings which are low in total carbon have not, to the author's knowledge, shown hard patches due to grinding.

Failures from Cans.

One of the most exasperating forms of failure, and also one of the most costly, is that due to collapse of annealing pans. During the process of annealing, generally on the second or third day, one of the lower cans in a stack will start to sag, causing the whole stack to lean over bodily, and in extreme cases, to fall into the firehole. The castings in that stack may then be written off as a total loss. Those which can be removed from the cans when the furnace is opened are usually so burnt and scaled as to be useless. It is always the can maker who gets the blame, and mostly with justification. It has been thought at times that the fault might lie with the man who has been firing the furnace. In the coal-fired, straight-through fireplace type of furnace, the coal may be fed on in such quantity, especially during the first 36 hours, that the fire is much higher than the top of the fireplace; that is, the bed level. The bottom cans are in actual contact with coal burning at full draught, and such serious local overheating may occur as to soften the sides of the annealing can, which collapses under the weight of the cans and castings above. Actual direct evidence of this has been observed. Failure from this cause is regrettable under any circumstances, but before blaming the material of which the can is composed it is as well to investigate closely the method of firing. Failures have been noted from both sources, that is soft cans and local overheating due to careless firing.

Closely allied to this is failure due to annealing ore partially fusing. This may be caused by local overheating, by using a packing mixture containing too high a proportion of red ore, or an ore of inferior quality. In connection with this latter point, a good ore should contain at least 85 per cent. ferric oxide. Many ores contain over 90 per cent. ferric oxide, but in inferior ores this constituent is low, the balance being made up by lime and silica. These tend to form a fusible mass at the high temperature attained in the annealing furnace, with the result that can, castings, and ore come out of the furnace as a solid body, and there is generally no alternative but to dump the lot on the scrap heap. Some time ago supplies of annealing ore came through which gave only 56 per cent. ferric oxide and over 35 per cent. lime and silica.

Presence of Scale may Cause Defects.

One other item which will cause the ore to fuse is the presence of admixed scalings from the cans. In emptying work out of annealing cans, cleanliness is essential, as it a very simple matter for pieces of scaling to become mixed with the black ore. All scalings should be kept away from ore, which must be screened before use. A lump of fused ore in which the nucleus was a piece of scaling has been observed.

Effect of Silicon.

It is a well-known fact that silicon has a marked effect on the annealing properties of malleable,

and as a general rule, the higher the silicon the softer the casting under the same heat treatment. There is, however, a limit to which the silicon content must go. During the war the author's concern was supplied in error with a pig which was high in silicon. Out of curiosity a few castings were made with a proportion of this material mixed with an ordinary low-silicon malleable pig. The castings, although very soft and machinable after annealing, were weak and easily broken. The fracture was practically identical with that of a "blackheart" casting, and on analysis showed: T.C., 3.00; Gr., 2.28; C.C., 0.72; Si., 1.17; S., 0.22; P., 0.07; and Mn., 0.55 per cent.

About the same time, owing to the deliveries of pig running very low in silicon and coke being of poor quality, a batch of castings was obtained which gave an analysis of 0.42 per cent. silicon and 0.45 per cent. sulphur. These refused utterly to anneal, although they were given three separate periods of seven days, in all twenty-one days' annealing. Eventually the whole batch of castings had to be scrapped. An endeavour is made to keep the silicon content round about 0.70 per cent. and the sulphur as low as practicable, *i.e.*, not more than 0.25 per cent. if possible. When these conditions prevail little trouble is found in producing soft castings, but accidents will happen even in the best regulated foundries.

Deductions from Slag Colour.

In connection with silicon content, there exists a rough but useful guide in the colour and condition of the cupola slag. It has been noticed repeatedly that if the silicon content is running about 0.70 to 0.80 per cent., the slag is a greyish-green in colour. If the silicon is below 0.70 per cent the slag varies from a dark bottle-green down to black for low silicon. With a silicon content above 0.80 per cent., the slag becomes a brighter green.

All Pig Irons do not Blend.

It is common practice in malleable foundries to work on two or more different brands of pig-iron. In the event of supplies of one brand failing, work can be carried on with the alternative brand. This is a very desirable state of affairs, but it has been found it has one curious disadvantage. Occasions arise where two brands of iron do not blend well together, although both may be similar types of hematite pig. Some time ago a sample lot of an untried particular brand of iron was received. Before using too heavily it was decided to try some tests on this iron. The standard brand of pig had been giving average tensile results of 24-tons ultimate stress, with a 4 per cent. elongation on a turned bar. The new brand, used alone, gave just over 24 tons ultimate stress, with 3.5 per cent. elongation on a turned bar. Using equal quantities of these two irons, we were surprised to get an average of less than 20 tons ultimate stress, with 1.5 per cent. elongation, and there was no appreciable increase in tensile with less than 80 per cent. of either brand. The author is still at a loss to understand this, as both the analysis of the iron and the test-bars were normal.

Failures may be due to errors in cupola practice, but this subject is so vast that it stands in a class by itself. However, it has been found in melting malleable that small charges give better and more uniform results than heavy charges: and every care should be taken to see that each charge is correctly weighed rather than the happy-go-lucky methods sometimes adopted by the man on the cupola stage of "so many pieces of pig and so many shovels of scrap."

Before concluding, it may be interesting to give some curious compositions of malleable castings, or what might be called freak analyses. A certain batch of castings were put through the shop, and samples tested after annealing. The castings were sound, easily machinable, and gave a good angle of bend before fracture. The minimum thickness was $\frac{1}{4}$ in. and the maximum $\frac{3}{16}$ in. Analysis gave a very low total carbon, of which all was in the combined state; that is, no free carbon was present. The actual analysis was as follows: T.C., 0.30; Gr., nil; C.C., 0.30; Si., 0.75; S., 0.27; P., 0.06; and Mn., 0.04 per cent. Subsequently a somewhat similar case arose, in which the analysis was: T.C., 0.27; Gr., 0.10; C.C., 0.17; Si., 0.52; S., 0.21; P., 0.04; and Mn., 0.10 per cent. Although the Rover concern has handled malleable castings for 16 or 17 years, the author has never before or since come across an apparently perfectly annealed casting with a very low total carbon and no annealing carbon. Finally, an instance of the variation on composition due to length of time at annealing temperature and rate of cooling. Three castings, all cast from the same shank, were marked A, B, and C respectively. "A" was heated up gradually over a period of 40 hours to 960 deg. C., maintained at that temperature for 78 hours, cooled evenly to 600 deg. C. over a period of 40 hours, then quickly to air temperature. "B" was heated up regularly over a period of 36 hours to 940 deg. C., maintained at that temperature for 86 hours, cooled evenly to 700 deg. C. over a period of 36 hours, then quickly to air temperature. "C" was heated up steadily over a period of 24 hours to 920 deg. C., maintained at that temperature for 103 hours, cooled evenly to 800 deg. C. over a period of 31 hours, then quickly.

It will be seen that each casting had a total time in the furnace, including heating up and cooling, of 158 hours. "A" was cooled quickly from 600 deg. C., "B" from 700 deg. C., and "C" from 800 deg. C. The analyses were as shown in Table I.:—

TABLE I.—*Showing Variations of Composition due to Heat Treatment.*

	"A."	"B."	"C."
Total carbon	3.34	2.06	1.28
Graphite	2.01	1.68	0.40
Combined carbon	1.33	0.38	0.88
Silicon	0.61	0.59	0.61
Sulphur	0.25	0.25	0.23

It will be noted that the longer the time at annealing temperature the lower the total carbon, yet each shows markedly, from the proportions of combined carbon and free carbon, the influence of rate of cooling.

In conclusion, it is worth while emphasising that the time for secrecy in foundry operations is past. The malleable trade, more than any other, has suffered from this secretiveness, and incalculable injury done. The difficulties met with in the production of malleable are many and varied, and to deal effectively with them one needs to be an incurable optimist.

Some of the deductions drawn from failures experienced may be wrong, and open to criticism; if they stimulate others to interest themselves in such problems, and discuss them frankly and publicly, truth will prevail. It is only by continued effort and striving after knowledge that "Men may rise on stepping-stones of their dead selves to higher things."

DISCUSSION.

MR. G. E. ROBERTS (Coventry Branch-President) said he was surprised that no reference was made in the Paper to phosphorus contained in malleable-iron composition. He welcomed the stress that was laid upon the necessity of manufacturing malleable-iron castings on a more scientific basis than in the past. It had been his good fortune during recent months to remove into new works where it had been possible to provide better facilities for the production of castings. Since that happy event greater pains had been taken to have the pig-iron, mixtures, etc., analysed and to keep more systematic control over annealing treatment. The result was that they had enjoyed an immunity from trouble which would not have been possible in any other circumstances. He agreed that for success they must abandon rule-of-thumb methods and apply scientific principles.

MR. H. L. REASON (President of the Institution) said that when Mr. Hurren was speaking of cores he began to wonder whether the oil-sand core had come to the assistance of the malleable ironfounder. Bearing in mind its porosity and the simple method of its making, it seemed to him that the oil-sand core must of necessity give them some help in the problem of making malleable-iron castings. The Institution was very much indebted to Mr. Hurren for the valuable work he had done as their representative on the British Engineering Standards Association. He had

represented them on the Committee for framing a specification in connection with malleable iron. That specification was nearly ready for issue. The industries of the British Empire would be greatly benefited by the standardisation resulting from the report. He hoped that the time was not far distant when research would discover some method of materially shortening the time occupied by dry annealing malleable castings.

Mr. A. Parsons called attention to the position of the smaller foundryman who combined malleable with other general work, using the same cupola, and inquired whether Mr. Hurren would advise making the malleable castings first or in the latter part of the run of the cupola.

Mr. D. Wilkinson said he would have been glad if Mr. Hurren had had something to say about the mechanism of annealing, a subject in which he (the speaker) had taken a great deal of interest. He, personally, had conducted experiments involving the use of a neutral packing material and admitting air at the bottom of the slack of pans. The oxidation of carbon from malleable castings was a delicate operation, if they were successfully to remove the quantity necessary and yet avoid oxidising the skin of the iron. The great difficulty was at the point at which air was admitted, where almost invariably one found a few badly scaled castings. Taking it for granted that the removal of the carbon was due entirely to its oxidation by atmospheric oxygen, they could perhaps say that if the atmospheric oxygen was admitted carefully the thing was possible. The difficulty was to prevent the local action he had indicated, but with care, and making the apertures sufficiently small and also not putting any casting immediately adjoining the aperture, he found it fairly easy to get a thoroughly annealed casting, with the proper proportion of carbon removed and yet avoid any oxidation.

By carefully mixing ordinary machine-shop swarf with the scale from the pans a mixture was finally obtained which was so satisfactory that for several years nothing else was used. A further experiment which was not carried out to any extent was to take the swarf and thoroughly rust it. This material gave very good results. A final experiment was to pack test bars in nothing but sand. He found it was possible to get good, soft, easily-machined castings with nothing but sand packing, but in the testing machine this particular material gave lamentably low results. Following that he took a coarse sand and admitted air carefully, and really first-class malleable castings were obtained. Owing, however, to the care necessary in the operation of admitting air, it was considered that the risk of damaging the casting was too great. In the making of American malleable iron he had seen it recommended that with a carefully selected iron it was possible to make excellent malleable with a neutral packing material. There were two phases of the ordinary annealing operation. There was the breaking down of the cementite, resulting in the production of a greyish casting and the removal of a certain amount of carbon, giving increased elongation. It would be a fruitful investigation to find out what bearing upon strength and elongation those two phases had. The result of his experiments was to show that the breaking down of the cementite gave a soft, easily-machined casting, while the removal of the carbon resulted in not necessarily strength, but certainly in increased elongation. If experiments could be carried out over a considerable period on those two points it was possible that we might arrive at results ensuring that European cast iron should give elongation equal to that obtained by the Americans. Quite a number of engineers would not use malleable iron because they said it did not give sufficient toughness, and they preferred light steel castings.

THE AUTHOR'S REPLY.

Replying upon the discussion, Mr. Hurren first referred to peeling, and expressed the opinion that it was more often due to an oxidising atmosphere in the annealing furnace than to any fault in the composition of the material. As to phosphorus, he did not think it worried the malleable trade to anything like the extent many other constituents did. He had never found a very high phosphorus content in any malleable pigs. It was usually about 0.1 or below, and consequently he had never had any trouble in that direction.

With reference to the new specification for malleable iron, he hoped the trade would appreciate it. There was a desire on the part of some members of the Committee to make the tests rather high and exclusive, but he thought they had been successful in getting out a specification that with care no firm would have any difficulty in meeting. He emphasised the value of oil-sand cores, remarking that several castings made by his firm could not be made without using either oil-sand or some similar quality of sand in the core. He agreed that in most instances hard spots which occurred where the runner or feeder had been ground off were due to insufficient annealing. He could not say that there was any difference in the quality of the material produced in coal-fired and gas-fired ovens, but he thought the annealing pans lasted longer in the case of gas-fired ovens. They were not so liable to an oxidising atmosphere, and were therefore more immune from scaling. The doping of pans added greatly to their life. As to porosity in the centre of pig-iron and its effect on castings, he said he had only once come across a batch of pig-iron in which there was any considerable porosity in centre. No ill-effects were noticeable in the castings. They did not like high manganese in malleable castings. When manganese exceeded 0.35 per cent. trouble could be expected. They endeavoured to reduce the manganese to 0.2 or 0.25 per cent. With reference to the placing of heavy castings in the hottest part of the oven, he pointed out that that was not always the highest part of the oven. In some ovens the hottest part might be at the bottom. What he meant more particularly was that in coal-fired ovens certain parts were always at a greater temperature than others. The centre of the oven was usually 50 or 60 degrees higher than the firing door and the back of the oven, and they endeavoured to place the heavy castings in the pans which would come more towards the centre of the oven. He did not recommend the melting of malleable iron in the cupola with other work, but in the few insfances where they had done it they had always melted the malleable iron first. They usually sold castings scrapped after annealing. Discussing the use of a neutral packing and the admission of air, he said they had used ordinary floor sand and found that they could get good malleable castings from it. It was quite possible to anneal castings without any packing material whatever provided the sulphur was kept fairly low. They obtained what was practically a blackheart fracture after annealing.

Catalogues Received.

Oil Pumps.—We have received from Messrs. Joshua Rea & Sons, Limited, of Collinwood Street Oil Works, Liverpool, a descriptive leaflet outlining "Senga" oil pumps. These are made in six sizes, and are fixed to the barrel or drum. At the base of the main cylinder and resting on the barrel is a drip tray. The use of such an apparatus eliminates waste and does away with the unsightly greasy stain to be found in most foundry oil stores. Obviously economies result from the use of such a contrivance.

Electric Heat-Treatment Furnaces.—A card with a detachable marling card is to hand from Messrs. Automatic and Electric Furnaces, Limited, of 173, Farringdon Road, London, E.C.1. The object of the card is to invite people interested in the heat-treatment of steel to avail themselves of a practical demonstration of the Wild-Barfield Resistance Furnaces.

Societe Miniere et Metallurgique de Penarroya.—This Franco-Spanish concern proposes to distribute a gross dividend of 27.50 fcs. per share (11 per cent.) for last year, compared with 22.50 fcs. (9 per cent.) the previous year.

An Apprenticeship Course in Foundry Practice.—XXXVIII.

By Ben Shaw and James Edgar.

SKELETON CORE-BOXES.

The principles of skeleton core-box construction having been covered in the last article, we shall show by describing a few core-boxes how these principles apply. It may be well to state that, though many iron, steel, or brass foundries will not accept skeleton patterns, the majority will accept skeleton core-boxes. This is because moulds are usually rammed, whereas cores can conveniently be made from core-loam, which does not need ramming. A skeleton core-box, therefore, is frequently supplied even though the pattern is solid.

Before describing skeleton core-boxes proper, it will be profitable to explain how, apart from strickles, core-frames and thicknessing core-boxes are sometimes eliminated.

Pipe-Bend Device.

Fig. 1 is shown not exactly as an ingenious curiosity, but as an interesting device to cope with a special condition. When pipe-bends are wanted urgently, it is common practice to provide the moulder with a skeleton pattern, and either a strickle and a guide or core-plate, or a skeleton core-box may be supplied. In either case the production of the casting in the foundry is frequently retarded because of the additional amount of work imposed upon it. In many instances the work in the foundry can be reduced to a minimum with very little, if any, additional labour in the pattern-shop, and it is usually the core-box on which a little more care can be profitably exercised. A quick method for preparing a core-box for an angled pipe is shown in Fig. 1. The pieces BB are secured to a bottom plate, and wedge-pieces cut to form the desired sweep are fixed between them. The desired shape is then marked out, and the pieces BB removed to be sawn and then returned to their former position. The wedge-pieces are numbered, so that they can be returned to their relative positions and removed to be sawn also. A jig or template, marked A in Fig. 2, cut so that it represents half the angle of the wedge-pieces, will be helpful when cutting the pieces at the band saw. If the saw is in good condition, and care is exercised in cutting, very little tool work will be required after the pieces are fitted together, and the foundry is then provided with an accurate core-box, in which the core can be made at once without any preliminary making-up or filling. A core-box so constructed is very conveniently altered when the angle of the pipe is required to be varied.

Fitting Branch Cores.

Another box device, which is more valuable than that just described, is a box which is really a fitting guide. When branch cores have to join on to an irregular shaped body core, either a special core-box has to be made or some means have to be provided for making the end fit. It is not common practice to supply plain small circular core-boxes, and the coremaker generally uses a stock core-box. The pattern-maker frequently neglects to provide any means for fitting the core. Let us suppose a 5-in. dia. core has to be fitted to an irregularly-shaped body. A square box should be made 5 in. across inside and in depth equal to the overall length of the core. The sides and ends of the box should be shaped to take a template All that the coremaker has then to do is to make a core in a stock box, dry it, then place it in the square fitting box and shape the end until the template fits. This is a device that lends itself to many purposes. Such a box and its template are shown in Figs. 3 and 4 respectively.

Globe Valve Core-Box.

In the last article emphasis was placed on the desirability, when making a cylindrical core or a core with cylindrical ends, of cutting the core through the ends of the box. This is not, however, always possible. It is often necessary, as, when the top half of a core is being strickled to shape the ends so that the strickle will bear on them. An example of this kind is shown at Fig. 20 in the issue of January 18 of the Journal.

Figs. 5 and 6 show one method of making a skeleton core-box for a large valve. In this case the core is cut through the ends, and the section pieces are fitted across the box. For a very large box this is perhaps the simplest construction, although it necessitates drawing each piece separately. In the case of a medium-sized box, or even the largest size, if one or two supports are fitted along the length of the core-box, the shape-defining pieces are run longitudinally, the great gain being that they can be cut from a template. Instead of supports along the length, the pieces may be carried to the sides and bottom of the box.

The outer case having been made, grounds should be made and screwed inside the ends. These should have semi-circular holes cut out 2 or 3 in. larger than the diameter of the core at the ends. A template should be made to follow the contour and having the ends checked to suit the grounds. In this case, as described above, it is better that the section pieces be sufficiently wide to fit against sides and bottom. These define the required shape of the core, and, when the intervening spaces have been filled in, many cores can be made in it without the necessity for repeating the filling-in process.

This form of skeleton core-box is capable of wide variation and is applicable in many cases when a full pattern is supplied for the mould. Fig. 7 is a plan view of the outer case and the end grounds, while Fig. 8 is a section of the box.

Core-Box for a Y-Pipe.

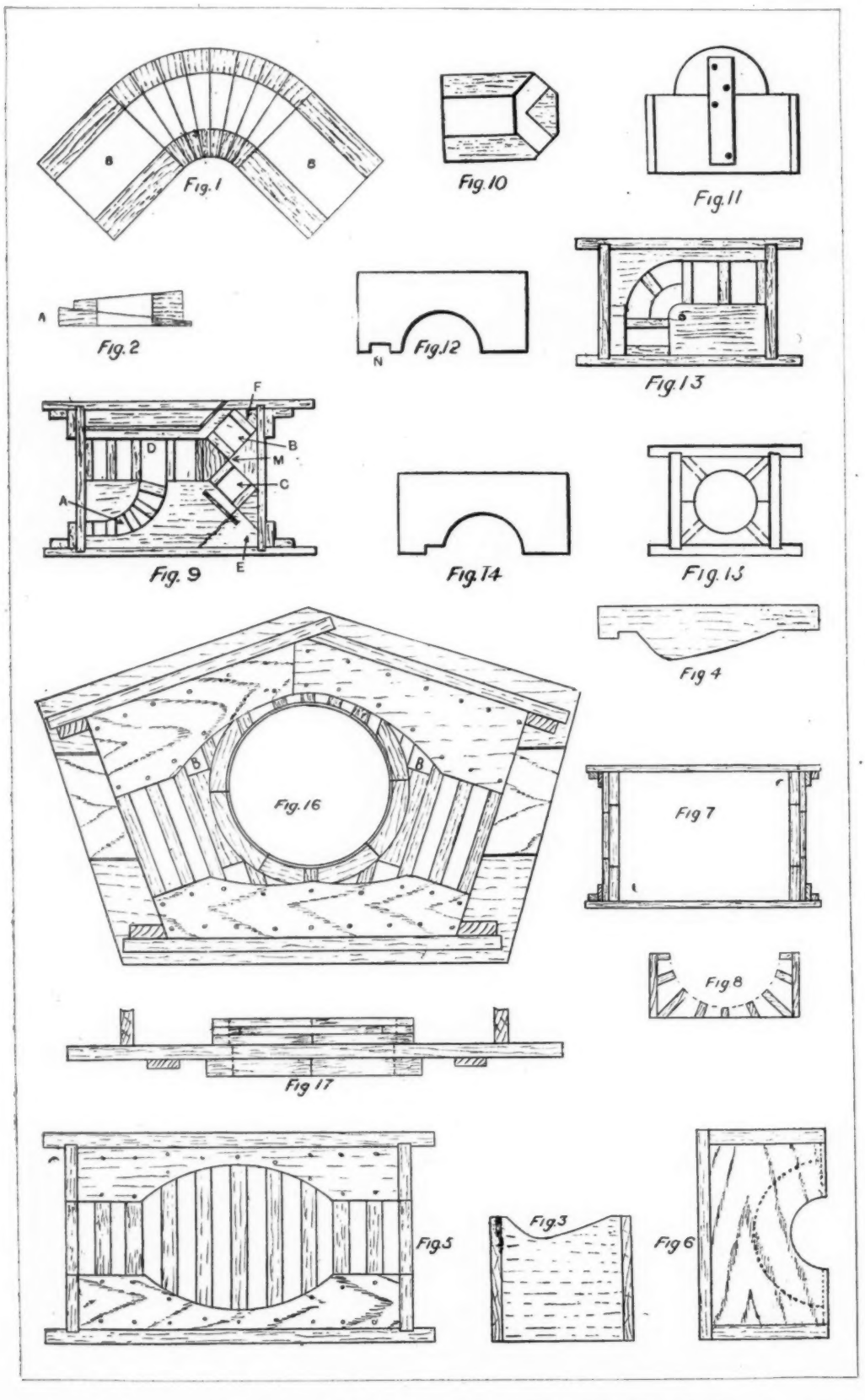
Fig. 9 shows a core-box for a Y-pipe with a tapered branch. This has been chosen because it comprises many of the difficulties with which the apprentice is faced in skeleton core-box work. It would not be necessary to make a full box for a pipe such as this; the top half, except for the tapered branch, can very well be strickled. For a full box, the core would be cut through the ends of the box; but, as only a half-box is being made, it will have closed ends. The shape of the core would have to be set down on the bottom, and also lines for the sides and ends. It would be necessary to fit two diagonal pieces, E and F (Fig. 9), for the branches B and C. The grounds could be kept about 2 or 3 in. apart. Two strips used as a gauge simplify the work of spacing the grounds. At the junction of the grounds B and C it is advisable to fit a solid block for the spherically-ended large core.

When the grounds had all been screwed in, centre lines would have to be raised from the bottom with a set-square, the grounds marked so that their places could be easily found again, and then taken out and the diameter of the hole drawn on. If a piece of timber of the same thickness as the grounds were used, and a line gauged on it $\frac{3}{4}$ in. back from the edge to allow for the thickness of the top plate, drawing on the circles will be a simple matter.

When the grounds were screwed finally into the box, the edge at the top plate could be trimmed and the top of the box planed straight. This would complete the bottom half of the box

It is impossible to strickle a tapered branch such as A, so a top box would have to be made for it. This top box would be made of four sides dowelled to the bottom part and filled with grounds corresponding to the grounds in the bottom part. It would be made to the edge of the body core D (Fig. 9). For the top half of the junction of the B and C branches, the better job would be to make a solid box like Fig. 10 and dowel it to the bottom, but many would prefer to strickle right

up to the point M (Fig. 9), and leave the finishing of the shape to the moulder. In order to strickle the remainder of the top, half-circle grounds would have to be fastened at the ends of the cores, as shown in Fig. 11, and strips ½ in. thick and ½ in. wide would have to be screwed on top of the box. The edge of the strip should be kept ¾ or 1 in. back from the edge of the core. The strickle is shown in Fig. 12, the slot N, of course, working on the narrow strips. The moulder would first fill inside the junction box, then strickle the straight cores with the tapered box off. He would then replace this box. The joining of this core to the body core on the circle could be left to the moulder. Of course, it is not always possible, as in this case, to keep the guide



strip for the strickle back from the edge of the core. When strickling bends, it is advisable always to work from the inside, it being obviously simpler for a moulder to swing the strickle from the centre. In strickling a very large bend, especially if it is a bend as in Fig. 13, it is worth while swinging the strickle from a centre dowel, another strickle being made for the straight. But in small bends the guide strip can be made to the edge of the core, and a strickle like Fig. 14 made. It is not always possible to make bends altogether with grounds. If it is a very quick bend, the grounds would probably have to be tapered to a knife edge. So a block would be cut to the centre line of the bend and grounds made to butt against the blocks for the outside, as in Fig. 13.

In many pipes, where the two halves of the core are exactly the same, the moulder would not strickle the top half, but would simply make two half-cores and secure them together afterwards. A circular or oval core, any diameter and a few inches deep, is often wanted. A solid box would be unwieldy, and a skeleton form would have the advantage of not warping to any great extent. It is not necessary to make a shallow box like this in halves. A frame would be made in the usual way, *i.e.*, the ends rebated into the sides and about 4 in. larger than the core. It should be of the exact depth of the core. Pieces of timber should now be screwed to the sides of the frame and flushed off top and bottom. They can be mitred at the corners. The hole can now be drawn and the pieces taken off and finished. It would be well to fit a support at each corner, as shown by dotted lines in Fig. 15.

An Angled Valve Core-Box.

In another article of this series we described the construction of a solid core-box for a large angled valve. Unless when a considerable number of castings are required, it is not usual to make a solid core-box. A skeleton core-box can be made very much cheaper, and if the student will master the constructional methods involved in the core-boxes already discussed and the following particulars of a large-angled valve core-box, he should be able to cope with most kinds of skeleton core-box making.

Fig. 16 is a plan of a suitable skeleton box. In order to strickle the top half of the box, it is advisable to make the cover branch core in the bottom half. The difficulty of sweeping up the round cover branch core on the top can be readily understood, and it would not be worth while strickling all that remained if a box were made for it. Thus, if the cover-branch core is not made in the full half-box, a full box may as well be made. The bottom, which is shown open jointed, is necessary. In the illustration, the box is shown much wider than it need be. On the bottom it is, in this case, almost necessary to set out the shape of the core-box on the joint, and, as the necessary sizes for the enclosing frame are thus seen, 1½-in. timber should be used for the frame, and this is a suitable thickness for the entire box. Fig. 17, which is a part section on the centre line of the core-box, shows a good method of making up the centre straight diameter. The bottom plate is cut through, and a thick ring of segments screwed on the underside to make the distance to the face of the print. This is better than making the bottom to the face, as it saves unnecessary building inside the box, and thus effects a considerable economy in timber. Inside, a segmental ring is better than section pieces. There is no difficulty in drawing off and making the shape-defining pieces for the branches or any other part of the box. The blocks BB (Fig. 16), between the segmental ring and the end of the straight branch, are better than thin section pieces. They ought to be finished in place. On the sides of the box the section pieces, because of the increased perpendicular straight, will rest on the built ring.

Bergslagen Ironworks.—A message from Stockholm reports a renewal of activity at the old ironworks in Bergslagen, Sweden, which ceased production in 1920. Several works unassociated with the Swedish Iron Works Association, and therefore unaffected by the lockout, have lately resumed work as a result of the increased demand for iron. The scarcity of charcoal, however, is limiting activity. The quantities of iron which had remained in stock since the stoppage have been speedily sold out.

Correspondence.

[*We accept no responsibility for the statements made or the opinions expressed by our correspondents.*]

Furnace Glasses.

To the Editor of The Foundry Trades Journal.

Sir,—The letter by "Smelter" on the difficulty of obtaining suitable glasses for melting was very interesting, but extremely difficult to understand owing to the indefinite manner of describing the required qualities.

Speaking from a limited experience, it is easy to appreciate how much each melter values his own glasses or goggles. He naturally becomes accustomed to the colours he sees through them, and finds it difficult, if not impossible, to make correct deductions from the various and varied appearances when using glasses other than his own—generally of a different colour.

When it is considered that each individual engaged in high temperature work selects his own glasses, which generally differ from everyone else's glasses, it will be realised that there is no standard glass, so that the makers of glasses are faced with a very awkward problem.

The most interesting point, however, was the note by the Editor regarding the harmful rays in the electric furnace. This can be enlarged, however, as harmful rays exist in various degrees in all thermal processes.

Few people realise that the most harmful rays—the infra-red and ultra-violet rays—are invisible, and are satisfied if they can obtain any dark glasses which will enable them to examine a source of heat without undue strain or fatigue.

The seriousness of this will be realised when it is stated that the outer membrane of the eye is easily impaired and damaged by radiation from the mercury arc, carbon or iron arc, and the oxy-acetylene flame.

"Glass blowers' cataract" is due to the "infra-red" rays according to Sir William Crookes.

The trouble is that the eye is incapable of detecting these harmful rays, and, furthermore, is incapable of selecting lenses which will afford the necessary protection.

This means that glasses must be scientifically designed and tested for industrial use.

The result of their work is extremely interesting. Cobalt blue glasses, which is about the most used glass, is exceedingly dangerous because it transmits all the infra-red and ultra-violet rays, just the same as ordinary glass. In fact, they say it should be abolished, though they admit the difficulty of training melters to a new colour.

They also say that it cannot be used for O.H. because they realise that practice would be seriously impaired if they insisted on its abolition. Nevertheless, it must be borne in mind that they are highly injurious, and the rising generation should have their glasses selected for them on a scientific basis. Red glass transmits infra-red rays, green glass the ultra-violet; smoked glass simply cuts down the intensity.

From this it will be seen that smoked glass and cobalt blue glass are highly dangerous—yet they are the most popular.

Regarding the constructive side, one American firm has already placed on the market glasses designed to cut out these harmful rays.

The writer believes that our own Department of Industrial and Scientific Research has also done something in this direction, but is unable to find a reference at present. As a point of interest, it is worth mentioning that the Americans have also carried out tests on glasses with "hot metal." and also tests with small steel pellets.

This is obviously an important matter to all concerned in high temperature work—people who are dependent on their eyes.

These remarks simply emphasise the importance of the correct selection of glasses, not only in tint, but also in their properties to hinder the transmission of harmful rays.

The Institute of British Foundrymen should take up this matter for the benefit of the trade and all concerned in it. It is thought that the Glass Research Association would gladly co-operate in any work undertaken on this matter, then the Institution could deal with the "users'" side of the question.— Yours, etc.,

Aneurin Rhydderch.

XUM

Vanadium in the Steel Foundry.

By J. Kent Smith, O.B.E., M.I.Brit.F.

Twenty years ago the element vanadium was beginning definitely to attract the attention of industrial metallurgists. Its existence had been recognised a century before that, although its original discoverer modified his first impressions and came to the conclusion that what he had thought to be a new element (and christened erythronium) was really the already known element chromium. And it would not be right to attribute too much blame to him on this score, since the chemical knowledge of those far-off days was scanty, and both elements have some chemical manifestations in common.

A generation later the element was rediscovered by another worker, and christened vanadium; this time its separate identity was placed beyond doubt. Scores of years passed by; our knowledge of the chemical attributes of vanadium was materially increased—especially by the magnificent work of Roscoe in the "sixties"—but with regard to its application little or nothing was done. Practically it was relegated to the shelf of the specimen cabinet. In the late "nineties" a chance observation led to a systematic series of trials, covering years, with regard to the potentialities of vanadium in steel metallurgy. As the result of those trials the manufacture in commercial quantity of the ferro-alloy of the element was begun; vanadium emerged from its obscure position in the curio cabinet, and attracted the serious consideration of the practical steel maker. To-day its ferro-alloy is produced in thousands of tons annually, its immense value is almost universally recognised by the modern steel maker, and the everyday utilisation of it in the steel industry is an accomplished fact.

How Vanadium Acts on Steel.

Avoiding, as far as possible, abstruse technicalities, let us first see how vanadium acts on steel. The author's remarks will be confined to that class of steels which is known as under-saturated—that is to say steels of "medium carbon"; these are the steels which almost exclusively interest the foundry from its producing point of view. "Under-saturated" steels in their make-up have aptly been compared with an igneous rock. A large proportion of their structure is composed of (structurally free) carbonless iron (ferrite). The actual carbon in the steel is *chemically combined* with a definite proportion of iron, and the chemical product resulting (carbide of iron) alloys itself—in more or less "sandwich" form—with another definite proportion of free iron; this alloy is called pearlite. The more carbon there is in the steel the greater is the quantity of pearlite obviously; in fact at a carbon content of 0.89 per cent. the whole of the free ferrite in a steel will have been required to form the alloy pearlite, and there results what is called a "saturated" steel. Those steels, however, in whose production the foundry is mainly interested, seldom have a carbon content exceeding one half—in most cases only one-third—of this amount; such steels, therefore, must consist of ferrite and pearlite particles interspersed.

It may be said that the strength or tenacity of a steel is mainly determined by the amount and character of its pearlite, and that its malleability, ductility and "life"—in other words resistance to deterioration by fatigue—depends upon the quantity and nature of its ferrite. Nearly all the alloys with which foundrymen are familiar act either upon one constituent or the other. Vanadium acts upon *both* constituents.

Briefly vanadium (1) acts as a scavenger, eliminating those very deleterious constituents oxygen and nitrogen; thus vanadium toughens indirectly. (2) A small quantity of vanadium enters directly into solid solution in the ferrite, directly toughening it—and consequently the steel. (3) The remainder of the vanadium enters into complex combination with the carbon, iron and manganese forming the carbides, and intensifying very much their strength. Thus vanadium strengthens steel.

Detailed Action.

(1) It should be noted that the scavenging action of vanadium is preferential; wherefore, vanadium alloy must never be added to molten steel until that steel has been as well deoxidised as possible by means of its manganese addition, and preferably by the subsequent addition of a little titanium. As the products of scavenging are carried away to the slag, and as those products contain their necessary proportion of vanadium, the importance of making the vanadium addition to steel, which has been as well finished as possible, does not need labouring.

(2) The direct solution of a little vanadium in the ferrite is, to the author's mind, an important point of theory and practice. That such does happen is definitely proved. Many workers at first contended that there was no such solution, but a large majority of them have since retracted their contention.

(3) Vanadium not merely intensifies the original strength of a steel (roughly in proportion to the amount and nature of the carbides to be acted upon) but also assists the annealing. The object of annealing is to effect the better distribution of the carbide particles in as fine and evenly distributed a form as possible, and avoiding colonisation as far as possible. The carbides containing vanadium seem to be somewhat more immobile in ferrite and colonisation of the carbides is thus prevented. In fact, a well-annealed vanadium steel is somewhat akin in its structure to an oil-tempered carbon steel, *without the deterioration of the ferrite itself which must automatically be brought about by oil tempering.*

Vanadium is used but little in this country in the preparation of castings; in the United States its application to the preparation of steel castings is very large. It may be asked why the use of vanadium in the manufacture of steel castings is not more general, and whether any bar to such use is raised by difficulty of application. The answers are (1) that no difficulty whatever arises in applying the right kind of ferro-vanadium, which is now so plentifully available, and (2) that the real reason is that the true service value of vanadium in the preparation of steel castings is not generally recognised in the testing house, they being seldom subjected to any other test than a static one.

Twenty years ago wrought steels seldom received any test of a dynamic nature; to-day the inclusion of such a test in specifications for wrought material is common. Castings specifications still include one but rarely.

Steel Castings and Forgings.

Medium-carbon-steel, as cast, even though annealed, has nothing like the dynamic value of the forged steel after annealing; while a well-annealed vanadium steel *casting* may be said to have approximately the same dynamic value as an annealed carbon steel *forging*.

The methods of use of vanadium in the steel foundry are extremely simple. Firstly, it is essential that its carbonless ferro-alloy be used. In the case of the open-hearth "acid" process of steel making being employed, particular attention is paid to the "finishing" of the bath and the condition of its slag. This slag should be slightly super-silicated in nature (a sample of it should break with a conchoidal—and not with a glassy—fracture) and the bath should be in good heat-condition. The manganese addition is then made *in the furnace*, and after a few minutes any ferro-titanium addition is made. Closely following this the addition is made of the necessary amount of ferro-vanadium to the furnace bath; during its addition the air supply is reduced. Within about three minutes the furnace can be tapped into the ladle as usual, any silicon-additions being made as in normal practice. In the case of the basic open-hearth process being used the charge is carefully "finished," the slag quieted, and the addition of manganese made *in the furnace* as before. The furnace is tapped, and the ferro-vanadium added to the stream flowing to the ladle, mixed preferably with a small quantity of carbonless ferro-titanium.

If the steel to be cast be prepared in the basic-lined electric furnace, exactly the same method of procedure as that advocated for the acid open-hearth may be employed. If the steel is to be cast from the crucible the metal, after being thoroughly "killed" in the fire, should have the titanium addition made about 20 mins., and the vanadium

addition about 15 mins., before pulling out and teeming. If a converter be used, the method of procedure advocated for the "basic" open-hearth is best followed, but it is quite permissible to follow the method of procedure advocated for the "acid" open-hearth process.

The quantity of vanadium best added to steel to be used in making castings is preferably 0.25 per cent., or 5½ lbs. of vanadium per ton of steel. As a commercial ferro-vanadium should contain roughly 40 per cent. of vanadium, this implies the addition of about 14 lbs. of it per ton of steel. About 0.05 per cent. (reckoned on the steel)—or, say, 1 lb. of vanadium—will be used up in legitimate scavenging work.

The vanadised steel will be found to pour from the ladle very quietly, and to feed well in the moulds. In the making of these latter no deviation whatever need be made from the ordinary "sand" practice of the foundry. With regard to shrinkage allowance, the shrinkage of vanadised steel is so nearly like that of plain carbon steel that no difference need be made in the patterns. In annealing the usual practice of the shop is followed. The best annealing temperature for castings in vanadised steel is 850 deg. C.; time considerations are exactly as usual.

Typical Results.

A maker and user of large reversing mill pinions several years ago sought the author's advice as to the best steel to use in their casting, being entirely dissatisfied with the pinions he was making and using. On learning that the addition of vanadium in his case to steel would only be expected to increase its tensile strength by 15 per cent., he expressed disappointment. It was pointed out to him that his troubles were really confined to the considerations of the limits of shock and wear. He admitted that if he made the steel soft enough satisfactorily to withstand shock for long periods the pinion teeth wore out, while, on the other hand, if he made them hard enough to give reasonable wear they broke in the large majority of cases.

The simple addition of vanadium to his softer mixture completely cured his troubles; the life of his mill-pinions was increased nearly 8 times, the output of his rolling mills was increased materially—due mainly to his having no stoppage for replacements—and his total rolling costs were decreased, consequent mainly to these two items, by a sum sufficient to cover many dozens of times his extra expenditure on vanadium.

Such an instance is only one typical of many, and similar improvements can be, and have been, effected in scores of other directions. Cast steel rolls are a notable case in point. In American foundry practice cast steel locomotive frames and the many vanadised steel castings entering into the construction of the locks of the Panama Canal are perhaps the most outstanding examples of the huge benefits to be derived from the considered use of vanadium in the steel foundry.

[It would have been interesting if the author had pointed out the reasons for his preference for low-carbon ferro-vanadium and ferro-titanium. We, ourselves, have known difficulties to arise in the machine-shop through hard spot when using high carbon, ferro-titanium, and ascribed, without definite reasoning, that the trouble was due to the existence of titanium carbides in the ferro alloy, which had never been assimilated by the steel. It would be interesting to learn whether it is thought that something of similar nature exists with ferro-vanadium. As it is doubtful whether oxygen, *per se*, exists in cast iron, and as the main object of ferro-vanadium and ferro-titanium is to remove this element, their effect on cast iron must be regarded in a totally different light.—Ed.]

Certificates of Origin for Spain.—The official "Gaceta de Madrid" publishes a decree according to which a large number of articles appearing in the import tariff will require certificates of origin on entering the country as from May 1. This step has been taken as a result of constant petitions on the part of representatives of Spanish commerce and industry, who complain of the unfair competition rendered possible by the absence of reliable indications concerning the country of origin of imported goods.

Book Reviews.

"The Generation and Utilisation of Cold: A General Discussion." Published by The Faraday Society, 10, Essex Street, Strand, London, W.C.2. Price 10s. 6d. net.

For foundrymen who are used to appreciate the significance of elevated temperatures, a work dealing with extreme cold is something of a novelty. Yet the subject is of vast metallurgical importance, and associated with this is a commercial side also. For instance, a consignment of mining tools divided between South Africa and Siberia developed numerous faults in the latter country on account of extreme cold. Two contributions from the pen of Mr. Cosmo Johns deal with metallurgical questions at low temperatures, and both emphasise the lack of knowledge at present existing.

The book is divided into two sections, the first dealing with laboratory methods of liquefaction, and the second with industrial methods of liquefaction and practical applications of low temperatures. Included in the list of contributors are some of the leading scientists of Great Britain. Whilst the subject is a little abstruse for the average foundryman, a careful perusal of the metallurgical section will indicate to him a direction where he may usefully turn for the purpose of acquiring fundamental knowledge.

"Copper Ores," by Robert Allen, M.A. (Cantab). Published by Mr. John Murray, Albemarle Street, London, W. Price 7s. 6d. net.

This work is one of the series of Monograph on Mineral Resources, with special reference to the British Empire, and issued under the direction of the Mineral Resources Committee of the Imperial Institute.

It is believed that during the war more than half the world's output of copper was used for military purposes. During the latter half of the war Germany could not obtain a sufficient supply for her needs, and, to a large extent, used such substitutes as electrolytic iron, aluminium, and zinc. It was thought that after the war the last two metals would largely replace copper, but they have not done so to the extent predicted, and the consumption of copper would appear to be steadily increasing.

The first chapter of the Monograph deals briefly with copper ores and their associations; the enrichment and classification of copper deposits: the mining and metallurgy, prices, properties and uses, control and world's production of the metal.

In the second chapter the chief copper deposits of the British Empire are described, particularly those of British Columbia, Manitoba, North-West Territories, and Ontario, in Canada; of Newfoundland; and of Queensland, South Australia, and Tasmania.

The third chapter deals with the principal copper deposits of foreign countries, notably Finland, Germany, Norway, Russia (including the Caucasus and Siberia), Spain, Yugo-Slavia, China, Japan, Korea (Chosen), Belgian Congo, Cuba, Mexico, United States, Argentina, Chile, and Peru.

The Monograph is illustrated with six diagrams and a map showing the copper-bearing localities referred to in the text, and has about 300 references to publications on copper.

Institution of British Foundrymen.

London Branch Programme Changes.

On Saturday, April 21, at the Institute of Marine Engineers, at 4 p.m., Mr. Oliver Smalley, of Newcastle-on-Tyne, is to lecture on "The Problem of the Permeability and Standardisation of Moulding Sands and the Venting of Cores and Moulds."

Mr. D. Sharpe, of Glasgow, has promised to deal with the Beardsley-Piper sand slinging machine on May 5. An invitation is extended to all interested in these two subjects.

Mr. H. J. Powell, an associate member of the Birmingham Branch of the Institution of British Foundrymen, is in Dudley Hospital as a result of an accident whilst following his occupation.

Trade Talk.

BALDWINS, LIMITED, are putting another of their furnaces into blast on basic pig-iron.

THE EGLINTON MAGNESITE BRICK COMPANY, LIMITED, have removed their offices from 45, Renfield Street, Glasgow, to the Dundyvan Brickworks, Coatbridge.

CHARLES J. FOX, LIMITED, iron, steel and metal merchants, formerly of Maryland Point, have removed to Stratford Wharf, High Street, Stratford, London, E.15.

THE WALLSEND SLIPWAY & ENGINEERING COMPANY, LIMITED, have taken an order for oil engines for one of three vessels to be built by the Furness Shipbuilding Company.

SIR HUGH DRUMMOND has been elected chairman for the ensuing year of the Railway Companies' Association, with the Hon. C. N. Lawrence as deputy-chairman.

THE WAGES regulated by the sliding scale under the Midland Iron and Steel Wages Board will be advanced 2½ per cent. from Monday, April 9, to Saturday, June 2.

A DISPUTE with regard to working conditions has culminated in the closing down of the furnaces at Gartsherrie Ironworks, Coatbridge, owned by Wm. Baird & Company, Limited.

WM. BEARDMORE & COMPANY, LIMITED, of Glasgow, have secured a contract for the supply, construction, and equipment of the general workshops of the Portuguese South and South-Western Railway at Barreiro.

BEFORE THE MEMBERS of the Sheffield Association of Metallurgists and Metallurgical Chemists, on March 27, Dr. T. Swinden delivered an interesting lecture on "The Embrittling Action of Some Salt Solutions on Mild Steel."

COX'S SHIPPING AGENCY, LIMITED, have removed their shipping and forwarding departments to Trafalgar House, 11/13, Charing Cross, S.W.1, and their insurance and chartering departments to 23, Lime Street, E.C.3.

AT A FOUNDRYMEN'S CONVENTION, to be held on April 30 at Cleveland, U.S.A., Dr. Percy Longmuir, of Sheffield, as representing the Institution of British Foundrymen, will submit a paper on "British Foundry Practice, Ferrous and Non-Ferrous."

A FIRE broke out, on March 30, in the works of the Steel Company of Scotland, Limited, at Hallside, Cambuslang. The outbreak originated in a tank which, with its contents, was completely destroyed, and also a part of the roof before the brigades were able to subdue the flames.

AN OUTBREAK OF FIRE occurred at the Globe Works, Barford Street, Birmingham, on the first floor of which were the works of the Supremoil Stove and Burner Company, the ground floor being occupied by Messrs. J. W. Wathen & Son, stampers and piercers. The damage was not serious.

HOLLINGS & GUEST, LIMITED, Thimble Mill Lane, Birmingham, are supplying a large, complete plant of hydraulic bending presses, pumps and accumulator, to the Butterley Company, Limited, Codnor Park Iron Works, Nottingham, for the manufacture of colliery wagons and general wagon work.

SIR W. G. ARMSTRONG, WHITWORTH & COMPANY, LIMITED, have formed a Belgian subsidiary, with the title Compagnie Belge Armstrong Whitworth Société Anonyme, and a capital of 100,000 fcs., divided into 200 shares of 500 fcs. each.

THE POWER-GAS CORPORATION, LIMITED, Stockton-on-Tees, have completed the construction and erection of a water gas plant for Synthetic Ammonia & Nitrates, Limited, of Billingham. The plant comprises three mechanical generators and auxiliaries, with a rated capacity of six million cubic feet of gas per day, and will represent the most modern practice in water gas production on a large scale.

SOME TIME AGO the discovery of hematite ore was reported from the State of Johore, the most southerly portion of the Malay Peninsula. Advance figures for mineral exports during the past year have just come to hand from official sources, showing that 111,367 tons of iron-ore were exported and 1,490 tons of tin-ore. In 1921 the export of iron-ore from Johore amounted to 74,250 tons, valued at £86,635. The whole of this ore went to Japan.

DURING MARCH Scottish shipbuilders launched 14 vessels of 38,005 tons, as compared with 10 vessels of 28,996 tons in February and 16 vessels of 30,543 tons in March of last year. The only contracts reported in Scotland during March were:—Messrs. Harland & Wolff, Govan, to build three motor cargo ships for Messrs. Andrew Weir & Company, of Glasgow, and one of 10,000 tons deadweight for the Nippon Yusen Kaisha, of Tokio; Messrs. Lithgows, Limited, Port-Glasgow, a motor ship of 10,000 tons deadweight, also for the Nippon Yusen Kaisha; the Greenock Dockyard Company, a large cargo steamer; and Messrs. George Brown & Company, Greenock, three small vessels.

Company News.

Hadfields, Limited.—Final dividend, 2½ per cent., making 5 per cent., free of tax, for year.

Manganese Bronze & Brass Company, Limited.—Ordinary dividend passed; carried forward, £11,762.

John Summers & Sons, Limited.—Balance, including £199,934 brought in, permits of £197,146 being carried forward.

Furness, Withy & Company, Limited.—Ordinary dividend, 5 per cent. per annum, or 6d. per share, free of tax.

Ransomes & Rapier, Limited.—Balance, £30,842; dividends, 6 per cent. on preference, less tax, and 7 per cent. on ordinary, free of tax; carry forward, £21,628.

J. R. Pearson (Birmingham), Limited, 35-39, Cowper Street, Birmingham.—Capital £10,000 in £1 shares (8,000 7½ per cent. (free of income-tax) cumulative preference). Brassfounders.

Minerals and Metals, Limited.—Capital £100,000 in £1 shares (50,000 preference and 50,000 ordinary). Solicitors: A. J. Greenop & Company, Bush Lane House, London, E.C.

G. E. Mortley Sprague & Company, Limited, 46, Nelson Road, Tunbridge Wells.—Capital £7,000 in £1 shares (6,250 ordinary and 750 non-cumulative participating 7 per cent. preference). Engineers.

James Cartland & Son, Limited.—Brought forward, £12,735; loss for the year, £1,561; interim dividend, 5 per cent. per annum on preference; balance, £9,299; final dividend, 5 per cent. per annum on preference; carry forward, £7,424.

Smith & McLean, Limited.—Profit, £5,632; brought forward, £17,373; total, £23,025; interim dividend on preference, 3 per cent. per annum, £2,278; final dividend on preference, 5 per cent. per annum, £2,343; carried forward, £18,403.

O'Loughlin & Horrax, Limited, Queen's Chambers, 5, John Dalton Street, Manchester.—Capital £500. Founders, mechanical engineers, manufacturers and dealers in fuel economisers, etc. Permanent directors: J. A. O'Loughlin, C. Horrax and W. M. Greaves.

Newton, Chambers & Company, Limited.—Profit, £63,549; brought forward, £41,420; total, £104,969; interim ordinary and preference dividends, 3 per cent., £18,387; final dividends, 7 per cent. (less tax) on both preference and ordinary, £42,904; carry forward, £43,677.

Obituary.

MR. MATTHEW HUNTER, a director and shipyard manager of the firm of Alexander Stephen & Sons, Limited, Linthouse, has died.

MR. W. H. WILLCOX, governing director of W. H. Willcox & Company, Limited, engineers' furnishers, etc., Southwark Street, London, S.E.1, died on March 26, in his 71st year.

MR. M. H. ROBSON, long connected with the Blyth Shipbuilding Company, Limited, has died at the age of 70 years. Mr. Robson was a native of Sunderland, and served his apprenticeship in a Wearside shipyard. Forty years ago he became associated with the Blyth Shipbuilding Company, with which he held various posts, including that of secretary.

Personal.

MR. G. TURNER has retired from the board of Cammell, Laird & Company, Limited.

MR. G. W. HAWKER has been elected a director of James Cartland & Company, Limited.

MR. G. H. EWART, Mr. J. W. Ewart, and Mr. S. Ewart have resigned from the offices of directors and managing directors of Ewart & Collis, Limited, and Mr. A. Sainsbury from offices of director and secretary.

MR. JAMES J. BENNETT, who, in partnership with his son, Mr. E. H. Bennett, has for many years carried on business as tinplate and metal merchants and agents at 88, Mosley Street, Manchester, under the style of James J. Bennett & Son, has retired. Mr. E. H. Bennett continues.

MR. M. J. WHITEHOUSE, a veteran leader of the iron trade, has been recently presented with a large silver salver by his colleagues in the South Staffordshire Ironmasters' Association on the occasion of his retirement from the management of John Bagnall & Sons, Limited, after a connection extending over sixty years. Mr. Whitehouse has long been one of the most familiar and respected figures on the Birmingham Iron Exchange.

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—The resumption of business in the Cleveland iron market after the holidays has brought little change in the general position of the trade, which remains in a condition of extreme stringency. This may be unquestionably attributed to the heavy drain on furnace production in satisfying export demand, as illustrated in the total shipments of pig-iron from the port of Middlesbrough (including Skinningrove 11,224 tons), which amounted during March to no less than 67,638 tons, as compared with 39,406 tons (including Skinningrove 5,664 tons) in February, an increase of 28,232 tons. The dominating factors in this increase are the active demand from the Continent and the sales, mostly of ferro-manganese, to the U.S.A. In the home market the effects of the inflation in the price of pig-iron—it has advanced by something like 35s. per ton since the close of 1922—has undoubtedly been to induce considerable caution among consumers, though many users, acting upon the assumption that lower prices would rule, have found themselves caught extremely short owing to the rise. Meanwhile, Cleveland makers are already committed for the great bulk of their make over April and May, and, indeed, right up to the end of the half-year. Prices are firmly held at previous levels, standard No. 3 quality readily commanding 127s. 6d. for any spot lots which become available, and a similar figure is quoted for any moderate quantities makers have to spare over the ensuing quarter. No. 1 stands at 132s. 6d., No. 4 foundry about 122s. 6d. to 125s., and No. 4 forge 117s. 6d. to 120s. per ton.

The strength of the Tees-side hematite market is fully maintained, makers finding it difficult to keep pace with home requirements and at the same time cope with the increasing inquiry from abroad. There are now practically no supplies available for April/May delivery, but it is still possible to book fair quantities for June shipment, mixed numbers for this date being quoted at 125s., and No. 1 at 126s. For spot lots as much as 127s. 6d. and 128s. 6d. respectively are demanded. In West Cumberland and North Lancashire Bessemer mixed numbers are now quoted at round £6 15s. per ton delivered at Glasgow and Sheffield, and £6 17s. 6d. per ton, f.o.t. Liverpool.

MANCHESTER.—The local market for foundry iron shows very little change. There is perhaps rather less reluctance amongst buyers with regard to recognising the present prices, consumers of foundry iron now realising that they will have to pay 22s. 6d. or 25s. per ton more for No. 3 pig-iron than they paid when they last bought. Some of the Midland furnaces are now asking £5 10s. per ton at the furnaces, but there are still Derbyshire furnaces who will accept orders for No. 3 based on £5 7s. 6d. at the furnace. The price is high from the Lancashire ironfounders' point of view, but compares favourably with the position of the user of Cleveland iron, who is now asked to pay 127s. 6d. per ton for the same class of iron.

THE MIDLANDS.—Consumers in this area are experiencing increasing difficulties in obtaining pig-iron supplies, neither producers nor merchants having apparently any parcels on offer, while consumers are complaining of contract deliveries delayed. To some extent the inconvenience has been relieved by the intervening holidays, during which deliveries have been suspended, but as many of the furnaces have been on reduced blast in the meantime, there will be little, if any, accumulation of stocks to supply the deficiency. Quotations meanwhile continue somewhat indefinite and unreliable, but it is possible that this week's quarterly meeting may determine a foundation for a more stable basis of prices than has been available for some time past.

SCOTLAND.—As previously reported, business in the Glasgow iron market continues somewhat irregular, the anticipated further expansion of the export trade having been checked for the time being. It is, however, satisfactory to note that smelters have sufficient business already booked to keep furnaces in blast for some time to come. Last week there was very little business put through, either local or export, and prices, though unchanged, continued firm at £6 f.o.t. furnaces and £6 5s. f.a.s. Glasgow. Consumers here continue to pursue a hand-to-mouth policy, buying very little in the expectation of lower prices.

Finished Iron.

Manufacturers having only resumed operations this week, there is very little fresh to report with regard to the general position of the trade. The tone of the market is, however, firm, and bar-iron makers as a rule are well provided with orders covering some time to come, while in the absence of Continental competition, due to the occupation of the German industrial districts, it is quite anticipated that some advance in prices of this and other classes of finished material may be announced at the quarterly meeting this week. The recent advance in wages under the ascertainment will doubtless also be taken into account in the readjustment of bar-iron prices, which might in any circumstances have been imposed in the face of a steady and growing demand for this description of finished material. This movement, it should be noted, has already been initiated by the Scottish bar iron-makers, who have decided to advance prices 10s. per ton, making the basis for crown quality £12 10s. per ton, delivered in Glasgow.

Steel.

Conditions in the steel trade continue firm, and so far there has been no check in demand, inquiries both on home and overseas account being in improving volume weekly. In the Sheffield steel market the call for basic billets is as keen as ever, and users are complaining that they are unable to secure adequate deliveries. The market for acid billets is also very firm. The quotations for basic billets are: Hard £10 15s., medium £10 10s., soft £10. Bessemer and Siemens acid billets both stand at £13. The demand for open-hearth steel continues strong, and makers' order books are well filled. A good deal of the overseas business offering is reluctantly refused, owing to the glut of orders in hand. Crucible steel is, perhaps, showing a little improvement, but the flow of business is still very meagre. So far as the restricted output permits, business in ferro-manganese is quite active, and there is now every evidence of a world shortage. In consequence of the scarcity and high costs of production, the makers have been compelled to advance their prices another £1 for home and £2 export, and the former is now on the basis of £17 for loose, with £1 extra for packed. The market for tinplates continues very firm, and prices are advancing. Most of the works have good order books, and are not anxious to book for forward delivery. Last week, in consequence of the advance in tin bars, tinplates were put up to 24s. per box f.o.b. works port as the official minimum. Prior to the meeting of the committee, tinplates were done at 25s. to 25s. 6d. per box, with some makers asking 26s. per box, f.o.b. works port.

Scrap.

With the general resumption of work after the holidays, there has been an increase in demand for scrap material, prices for which fully maintain their recent strength. The present famine conditions in pig iron are certainly favourable to demand for scrap, and founders are finding a substantial advantage in price in securing supplies at current rates, cast-iron qualities being available in Lancashire markets at from 95s. to 100s. per ton, as contrasted with quotations for pig-iron from 107s. 6d. per ton at the Derbyshire furnaces to 122s. 6d. to 127s. 6d. in Cleveland and Scotland. It is evident, therefore, that good cast-scrap is 12s. 6d. to 17s. 6d. per ton lower than it ought to be. At present many ironfounders are consuming stocks of pig-iron bought at 20s. below the present price; but they will soon be working on current quotations, and then dealers in scrap will probably be able to sell at nearer actual value. In Scotland the demand for cast-iron scrap of all descriptions is very strong, and at the moment there are no tangible signs of any diminution of consumption. Heavy machinery metal and scrap railway chairs are being offered and accepted at 120s., and ordinary cast-iron 110s. Light metal and furnace firebars continue at about 85s. to 87s. 6d.

Metals.

Copper.—Movements in standard copper during the past week have developed an irregular tendency, due in part measure to the intervening holidays in conjunction with realising dealings on a somewhat extensive scale. Values, however, have only been subject to unimportant variations, and with demand from home consumers remaining fairly active, the tone throughout has continued firm and the turnover quite on an average scale. The American market remains firm, with higher prices anticipated eventually, with the latest quotation for electrolytic New York 17.25 cents per lb. Current quotations:—*Cash*: Wednesday, £74 17s. 6d.; Thursday, £74 15s.; Friday, £74 5s.; Monday, £73 5s.; Tuesday, £73 7s. 6d. *Three Months*: Wednesday, £75 12s. 6d.; Thursday, £75 10s.; Friday, £75; Monday, £74; Tuesday, £74 5s.

Tin.—Values in this section of the market are somewhat erratic, but have recently taken a distinctly lower tendency, presumably based on heavy sales and realisations on profit-taking account. Messrs. Henry Bath & Son, Limited, in their fortnightly report state: America continues to consume large quantities of tin, and the buying from that quarter, which fell away at the beginning of the fortnight, will doubtless be resumed before long. The demand for home consumption is only moderate, while inquiries from the Continent remain on a small scale. The East has sold moderate quantities at full prices. The visible supply of tin on the 31st ult., according to one authority, amounted to 21,703 tons, being a decrease of 480 tons compared with the figures on February 28. Current quotations :—*Cash* : Wednesday, £214; Thursday, £212 10s. ; Friday, £214 10s. ; Monday, £213 17s. 6d. ; Tuesday, £215. *Three Months* : Wednesday, £214 10s. ; Thursday, £213 5s. ; Friday, £215 5s. ; Monday, £214 15s. ; Tuesday, £215 15s.

Spelter.—The authority above quoted reports in regard to this metal the market experienced a setback in the early part of the fortnight, extensive realisations causing a fall in price which took values down to £35 5s. by the 27th ult. Since then there has been some recovery, which has not been entirely held. The approach of the holidays caused a falling-off in consumers' demand, while supplies from the Continent are becoming more plentiful. Dealings in this market are mainly of a professional nature at present. Current quotations :—*Ordinary* : Wednesday, £35 12s. 6d. ; Thursday, £35 12s. 6d. ; Friday, £35 2s. 6d. ; Monday, £33 17s. 6d. ; Tuesday, £35.

Lead.—Apprehension of strike differences in the building trade had at first a weakening effect upon the market for soft foreign pig, but this has since been followed by renewed strength, and prices are now comparatively firm. Current quotations :—*Soft foreign (prompt)* : Wednesday, £28 5s. ; Thursday, £28 5s. ; Friday, £28 7s. 6d. ; Monday, £27 17s. 6d. ; Tuesday, £27 17s. 6d.

Foundry Queries.

Cored Iron Rollers,

A difficulty is being experienced in moulding some iron rollers. The casting is 24 in. × 6 in., with a 5½ in. dia. core running through containing an arbor iron. The roller is moulded off a plate, yet in spite of a clean mould and well-skimmed metal—not too hot—we are troubled with dirty-holes in the casting after ⅛ in. has been turned off, this being the finished size of the casting. The casting is run at one end with a riser at the other. Now and again we get a small blow from the mould just as the riser is filling up, which generally results in a blow hole.

The mixture is composed of Si, 2.75 to 3.00; S, under 0.1; P, 1.00 to 1.25; and Mn, 0.8 to 1.00 per cent. We have tried adding 3 ozs. of aluminium to 1¼ cwts. of metal, this being sufficient to run two rollers. The result was worse than before—both castings being pitted with hundreds of pin holes. Later we tried a smaller quantity, with slightly better results, but in each case the castings were very hard. The composition of the mixture is for light castings, which require no machining. Could any of of your readers advise me on the matter?—X.Y.Z.

[X. Y. Z. when adding 0.13 per cent. of aluminium was undoubtedly using an excessive quantity. He should state (1) Type of core and how made and vented. (2) Type of sand and facing. As a preliminary experiment we would suggest vertical moulding and running from the top with hot metal through a pencil runner, using a filter core such as has been described by Mons. Ronceray.—EDITOR.]

Cupola Preservation.

Mr. W. Sutcliffe, of Bolton, writes, in answer to K. E. W.'s query as to a suitable coating for treating cupolas externally, that he has found the quick-drying bituminous black varnish made by Messrs. James Ross and Company, Limited, Lime Wharf Chemical Works, Falkirk, far preferable to ordinary tar. "London Foundryman" has satisfactorily replaced tar by "Bitumastic"—a protective coating made by Messrs. Wailes Dove Bitumastic, Limited, of Newcastle. Further, Messrs. Chemical and Technical Engineering Company, Limited, of 11, Pancras Lane, Queen Victoria Street, London, E.C.4, inform us that they have recently introduced a paint for this purpose. No doubt K. E. W. will find a suitable substitute for tar amongst these manufactures.

Institution of British Foundrymen.

West Ridings of Yorkshire Branch Annual Meeting.

The Branch held their second annual meeting in the Market Tavern, Bradford, on April 7. The secretary stated that since last annual meeting the membership had increased by 35, including five passed by the Council that evening, and there was now a membership of 80—one subscribing firm, and 35 members and 45 associate members. The Branch had just managed to keep its expenses within the allowance, although there is a wide district to cover.

The syllabus for the past session had been a very good one. The lectures and papers had been of a high standard. The attendances of members was fairl good; an average of 60 was reached, but this ought to be improved, and by a little more personal contact next session should prove more popular.

The following were elected to fill the offices and Council for ensuing year:—President, A. A. Liardet (Bradford); Vice-Presidents, J. G. Robinson (Halifax) and W. H. Poole (Keighley); Council, W. Slingsby (Keighley), J. J. Watson (Huddersfield), H. Summersgill and W. G. Thornton (Bradford), H. Sayers (Leeds), J. Wood (Wakefield), J. Boyle (Stanningley), W. Parker (Halifax), J. W. Sykes (Gomersal); Secretary, A. Love.

A smoking concert followed, and an excellent programme was supplied by Messrs. W. Kimber, baritone (Manchester College of Music); J. Hall, entertainer, and E. Reeves, tenor and pianist.

The new branch is to be congratulated on the excellent progress attained, due in a large measure to the efforts put forward by Messrs. A. A. Liardet, the branch president, and Mr. A. Love, the honorary secretary.

GANISTER, CUPOLA BLOCKS, FIRE BRICKS,
FIRE CLAY.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
STEEL MOULDERS' COMPOSITION, SILICA CEMENT.
J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.
Telegrams: "LOWOOD, DEEPCAR."

Telephone: 21, Penistone. Telegrams: "Durranns, Penistone."

ESTABLISHED 1863.

JAS. DURRANS & SONS., LTD.

Phoenix Works, Penistone NEAR SHEFFIELD.

BLACKING
PLUMBAGO
CORE GUM
WHITE DUST
COAL DUST

Manufacturers of

FOUNDRY EQUIPMENTS.

Ladles, Cupolas, Fire Bricks, Ganister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Write for illustrated catalogue on Blacking and Foundry Requisites, also for our latest Price List.

SIEMENS' STEEL PROCESS

BOILER, SHIP and BRIDGE PLATES, etc. ANGLES and all forms of Sectional Bars. TYRES and AXLES to all requirements. CASTINGS of all kinds and of Largest Sizes. FORGINGS of every description. BILLETS, BLOOMS, RAILS.

SPECIAL STEEL FOR CONSTRUCTIVE PURPOSES.

The STEEL COMPANY OF SCOTLAND, Ltd.

Head Office: 23, ROYAL EXCHANGE SQUARE, GLASGOW.
Works: HALLSIDE, NEWTON and BLOCHAIRN, GLASGOW.
CONTRACTORS TO HOME, COLONIAL AND FOREIGN GOVERNMENTS.

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LILLESHALL COMPANY LIMITED.

Cold Blast PIG IRON

Foundry and Forge qualities, also qualities highly suitable for Chilled and Grain Roll making, specially strong Castings and Locomotive and other Cylinders, &c., &c.

BRAND "LILLESHALL LODGE C.B."

ALL MINE HOT BLAST PIG IRON Foundry and Forge qualities.

BRAND LILLESHALL H.B.

PRIORS LEE HALL, Near SHIFNAL, SALOP.

Telephone—28 OAKENGATES.

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	73	7	6
Three months	74	5	0
Electrolytic	82	0	0
Tough	77	10	0
Best selected	77	10	0
Sheets	106	0	0
India	93	0	0
Wire bars	82	5	0
Do. Apr.	82	5	0
Do. May	82	5	0
Ingot bars	82	5	0
H.C. wire rods	86	0	0
Off. aver., cash, Mar.	73	18	4
Do. 3 mths., Mar.	74	12	2½
Do. Settlement Mar.	73	18	1½
Do. Electro, Mar.	81	14	7½
Do. B.S., Mar.	77	7	9½
Aver. spot price, copper, Mar.	73	17	3½
Do. Electro, Mar.	82	0	0
Solid drawn tubes		14½d.	
Brazed tubes		14⅜d.	
Wire		11¼d.	
Yellow metal rods		7½d.	
Do. 4x4 Squares		9d.	
Do. 4x3 Sheets		10d.	

BRASS.

Solid drawn tubes	13d.
Brazed tubes	14½d.
Rods, drawn	11½d.
Rods, extruded or rolled	7½d.
Sheets to 10 w.g.	11d.
Wire	11d.
Rolled metal	10½d.

TIN.

	£	s.	d.
Standard cash	215	0	0
Three months	215	15	0
English	215	0	0
Bars	217	0	0
Chinese	215	0	0
Straits	225	0	0
Australian	220	0	0
Eastern	221	10	0
Banca	218	10	0
Off. aver., cash, Mar.	219	15	0
Do. 3 mths., Mar.	220	18	10½
Do. Sttlment, Mar.	219	15	0⅞
Aver., spot, Mar.	219	13	4

SPELTER.

	£	s.	d.
Ordinary	34	18	9
Remelted	32	0	0
Hard	28	0	0
Electro 99.9	41	0	0
English	35	12	6
India	29	10	0
Prime Western	35	5	0
Zinc dust	49	10	0
Zinc ashes	13	10	0
Off. aver., Mar.	36	15	4½
Aver., spot, Mar.	36	14	4¼

LEAD.

	£	s.	d.
Soft foreign ppt	27	15	0
English	28	15	0
Off. average, Mar.	28	15	1¼
Average, spot, Mar.	28	16	3¾

ZINC SHEETS, &c.

	£	s.	d.
Zinc sheets, English	43	0	0
Do. V.M. ex whf.	42	0	0
Dutch	42	0	0
Rods	50	0	0
Boiler plates	41	0	0
Battery plates	42	0	0

ANTIMONY.

	£	s.	d.
English regulus	30	10	0
Special brands	36	15	0
Chinese	27	10	0
Crude	20	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver	11	10	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
45/50%	£13 0 0
75%	£20 15 0
Ferro-vanadium—	
35/40%	16/9 to 17/- lb. va.
Ferro-molybdenum—	
70/75% c. free	9/6 lb. mo
Ferro-titanium—	
23/25%, carbonless	1/2½ lb.
Ferro-phosphorus, 20/23%,	£28 10
Ferro-tungsten—	
80/85%, carbon free	1/5½ lb.
Tungsten metal powder—	
98/99%	1/10½ lb.
Ferro-chrome—	
4/6% car.	£23 10
6/8% car.	£22 10
8/10% car.	£21 10
Ferro-chrome—	
Max. 2% car.	£52 0
Max. 1% car.	£62 0
Max. 0.70% car.	£72 0
67/70%, carbonless	1/6½ lb.
Nickel—99%, cubes or pellets	£130 0
Cobalt metal—98/99%	12/- lb.
Aluminium—98/99%	£105
Metallic Chromium—	
96/98%	4/6 lb.
Ferro-manganese (net)—	
76/80%, loose	£17
76/80%, packed	£18
76/80%, export	£18
Metallic manganese—	
94/96%, carbonless	2/- lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	s. d. 2 6
Finished bars, 18% tungsten	3 0

Per lb. net, d/d buyers' works.

Extras—
Rounds and squares 3 in. to 8 in. inclusive 4d. lb.
Rounds and squares under ½ in. to ¼ in. 3d. lb.
Flats under 1 in. by ¾ in. to ½ in. by ¼ in., and all sizes over four times in width over thickness 3d. lb.
Bevels of approved sizes and sections 6d. lb.
If in coils 3d. lb.
Bars cut to length 10% extra

Scrap from high-speed tool steel—
Scrap pieces 3d.
Turnings and swarf 1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—						
Heavy steel	5	2	6	5	10	0
Bundled steel & shrngs.	4	7	6	4	10	0
Mixed iron & steel	4	10	0	4	15	0
Heavy cast iron				4	10	0
Good machinery for foundries				4	10	0
Cleveland—						
Heavy steel				4	17	6
Steel turnings				3	7	6
Cast-iron borings				3	7	6
Heavy forge				5	10	0
Bushelled scrap				4	15	0
Cast-iron scrap				5	2	6
Lancashire—						
Cast-iron scrap				5	0	0
Heavy wrought				5	5	0
Steel turnings				3	12	6

London — Merchants' buying prices delivered yard.

	£	s.	d.
Copper (clean)	67	0	0
Brass (clean)	38	0	0
Lead (less usual draft)	25	0	0
Tea lead	23	0	0
Zinc	25	0	0
New aluminium cuttings	70	0	0
Braziery copper	57	0	0
Gun metal	50	0	0
Hollow pewter	180	0	0
Shaped black pewter	100	0	0

PIG-IRON.

N. E. Coast—	
Foundry No. 1	132/6
Foundry No. 3	127/6
Forge No. 4	120/-
Mottled	—
Hematite No. 1	128/6
Hematite M/Nos.	127/6
Midlands—	
Staffs. common	—
,, part-mine forge	—
,, ,, foundry	—
,, Cold blast, ord.	190/-
,, ,, roll iron	200/-
,, basic	—
Northants forge	95/-
,, foundry No. 3	110/-
,, basic	105/-
Derbyshire forge	100/- to 105/-
,, foundry No. 3	115/-
,, basic	115/-
Scotland—	
Foundry No. 1	125/-
,, No. 3	120/-
Hematite M/Nos.	127/6
Sheffield (d/d district)—	
Derby forge	—
,, foundry No. 3	—
Lincs. forge	110/-
,, foundry No. 3	115/-
,, basic	—
E.C. hematite	137/9
W.C. hematite	135/-

All d/d in the district.

Lancashire (d/d eq. Man.)	—
Derby forge	—
,, foundry No. 3	125/-
Northants foundry No. 3	—
Cleveland foundry No. 3	—
Staffs. foundry No. 3	—
Lincs. forge	—
,, foundry No. 3	—
Dalzell, No. 3	137/-
Summerlee, No. 3	137/-
Glengarnock, No. 3	137/-
Gartsherrie, No. 3	137/-
Monkland, No. 3	137/-

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.
Bars (cr.)	£12 to 12	10	0
Angles	12	5	0
Tees to 3 united ins.	12	10	0
Nut and bolt	11	12	6
Hoops	15	0	0
Marked bars (Staffs.)	14	0	0
Gas strip	£12/5 to 12	10	0
Bolts and nuts, ¾ in. × 4 in.	20	10	0
Steel—			
Ship plates	10	10	0
Boiler plates	14	0	0
Chequer plates	11	5	0
Angles	10	0	0
Tees	11	0	0
Channels	10	10	0
Joists	10	0	0
Rounds & squares 3 in. to 5½ in.	12	5	0
Rounds under 3 in. to ¾ in.	12	0	0
Flats, over 5 in. wide and up	12	10	0
Flats, 5 in. to 1½ in.	11	15	0
Rails, heavy	10	10	0
Fishplates	14	10	0
Hoops (Staffs.)	13	0	0
Black sheets, 24 g.	14	10	0
Galv. cor. sheets, 24 g.	19	10	0
Galv. fencing wire. 8 g. plain	18	5	0
Rivets, ¾ in. dia.	14	15	0
Billets, soft	10	0	0
Billets, hard	10	15	0
Sheet bars	£9/11/6 to 10	0	0
Tin bars	10	0	0

PHOSPHOR BRONZE.

	Per lb. basis.
Strip	1 4
Sheet	1 4½
Wire	1 5½
Rods	1 3½
Tubes	1 7
Castings	1 2

Delivery 3 cwt. free to any town.

10% phosphor copper, £40 above price of B.S.

15% phosphor copper, £50 above price of B.S.

Phosphor tin (5%), £30 above price of English ingots.

CHARLES CLIFFORD & SON, LIMITED, BIRMINGHAM.

NICKEL SILVER, SHEET METAL, WIRE AND TUBES.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/4 to 1/10
To 18 in. wide	1/4½ to 1/10½
To 21 in. wide	1/5½ to 1/11½
To 25 in. wide	1/6½ to 2/0½
Ingots for spoons and forks	9d. to 1/3
Ingots rolled to spoon size	1/- to 1/6
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	33.14
No. 2 foundry, Valley	31.00
No. 2 foundry, Birm.	27.00
Basic	32.77
Bessemer	32.77
Malleable	32.77
Grey forge	32.27
Ferro-manganese 80% delivered	120.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y, at mill	43.00
Bess. billets	45.00
O.-h. billets	45.00
O.-h. sheet bars	45.00
Wire rods	50.00
	Cents.
Iron bars, Phila.	2.82
Steel bars	2.50
Tank plates	2.50
Beams, etc.	2.50
Skelp, grooved steel	2.35
Skelp, sheared steel	2.35
Steel hoops	3.30
Sheets, black, No. 28	3.85
Sheets, galv., No. 28	5.25
Sheets, blue an'l'd, 9&10	3.25
Wire nails	2.90
Plain wire	2.65
Barbed wire, galv.	3.70
Tinplate, 100-lb. box	$5.50

COKE (at ovens).

Welsh foundry	40/- to 45/-
,, furnace	30/- to 35/-
Durham & North. fdy.	45/-
,, furnace	38/-
Other Districts, foundry	45/-
,, furnace	35/-

TINPLATES.

f.o.b. Bristol Channel ports.

I.C.Cokes,	20×14, box	26/-
,,	28×20, ,,	52/-
,,	20×10, ,,	39/-
,,	18¾×14, ,,	26/9
C.W.	20×14, ,,	23/9
,,	28×20, ,,	47/6
,,	20×10, ,,	34/-
,,	18¾×14, ,,	24/-
Terneplates	28×20, ,,	46/6

TUBES.

	Up to and incl. 6 in.	
Gas	57½%	Tube prices are now free.
Water	52½%	
Steam	47½%	

SWEDISH IRON.

Bars, hammered basis sizes—Basis price £22 to £23

Rolled Ordinary—Assortment .. £ s. d.

Nail Rods—Square, round and flats .. 17 5 0 to 17 15 0

Keg Steel nom. £38 to £40

Faggot Steel nom. £30 to £32

Blooms—Single welded .. £10 to £11

Billets—Single and double welded .. .. £13 to £14

Pig-iron—Grey, white or mottled £6 15 to £7 5 0

Prices are without engagement. All quotations are f.o.b. Gothenburg, net cash against documents there.

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£	s.	d.		
April 4	74	17	6	dec.	12/6
„ 5	74	15	0	„	2/6
„ 6	74	5	0	„	10/–
„ 9	73	5	0	„	20/–
„ 10	73	7	6	inc.	2/6

Electrolytic Copper.

April 4	83	0	0	no change
„ 5	82	15	0	dec. 5/–
„ 6	82	10	0	„ 5/–
„ 9	82	0	0	„ 10/–
„ 10	82	0	0	No change

Standard Tin (cash).

April 4	214	0	0	dec.	100/–
„ 5	212	10	0	„	30/–
„ 6	214	10	0	inc.	40/–
„ 9	213	17	6	dec.	12/6
„ 10	215	0	0	inc.	22/6

Tin (English ingots).

April 4	214	0	0	dec.	100/–
„ 5	212	10	0	„	30/–
„ 6	214	10	0	inc.	40/–
„ 9	214	0	0	dec.	10/–
„ 10	215	0	0	inc.	20/–

Zinc Sheets (English).

April 4	43	0	0	No change
„ 5	43	0	0	„
„ 6	43	0	0	„
„ 9	43	0	0	„
„ 10	43	0	0	„

Spelter (ordinary).

April 4	35	12	6	dec.	10/–
„ 5	35	12	6	No change	
„ 6	35	2	6	dec.	10/–
„ 9	33	17	6	„	25/–
„ 10	34	18	9	inc.	21/3

Lead (English).

April 4	29	5	0	No change	
„ 5	29	5	0	„	
„ 6	29	5	0	„	
„ 9	29	0	0	dec.	5/–
„ 10	28	15	0	„	5/–

AVERAGE MONTHLY PRICES OF WEST COAST HEMATITE MIXED NUMBERS.

Year.	Jan.	Feb.	March.	April	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Yearly Average.
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
1885	44 0	44 1	43 2	43 1	42 10	42 6	42 6	42 0	42 2	42 1	43 0	43 8	42 11½
1886	43 3½	42 0	42 0	41 6½	41 2½	40 0	40 0	41 2½	41 6	44 0	44 0	44 9	42 2½
1887	49 6	48 9½	45 6	43 2½	43 6½	44 1	44 0	44 2½	43 5½	41 6	41 9½	45 0	44 0½
1888	44 4	42 3	42 1½	42 0	41 2½	42 1½	42 6½	44 0	45 8½	44 6	44 6	45 3½	43 4
1889	44 4	45 2	47 3½	48 9½	48 6½	48 7½	50 1½	53 11	55 3	63 6	73 10	73 2	54 4½
1890	76 1½	65 1	63 3	55 1	53 9½	50 11	52 3½	56 4	58 0	58 2	57 5	54 4½	58 5
1891	52 9	50 10	48 11	47 9½	51 5	50 6	50 10	48 4	50 1	49 1½	48 3½	47 8	49 8½
1892	47 4	45 6	46 4½	47 8	49 5	50 4½	49 7½	49 10½	49 10½	48 8½	46 10	46 1½	48 2½
1893	46 0½	45 8	45 11	45 7	44 11	44 9½	44 10	45 3	45 0	44 6	44 7	45 8	45 3
1894	45 3	45 3	45 1½	45 1	43 11	43 11	43 9½	44 2	44 7½	43 7	43 5	43 3	44 3½
1895	42 8	42 5½	42 6	42 10	43 10	43 7½	44 10	45 11	49 11	48 9	47 7½	47 7½	45 2½
1896	47 0	48 9	48 9	48 2½	47 3	47 3	46 10	46 10	47 2	48 5	50 7	50 6	48 1½
1897	51 2	49 10	48 5	47 4	47 9½	48 6	47 0	47 3	47 3	47 0	48 3½	47 11	48 2
1898	48 9	48 10	49 4	49 8½	50 10	50 3½	51 0	52 5	53 11	55 8	57 3	56 10	52 1½
1899	59 1	59 9	57 7	59 6	64 7	70 10½	76 7½	72 2	74 3	75 0	78 1½	73 3	68 5
1900	75 3½	76 10	79 10	84 6	81 4	79 1½	83 4	81 5	79 11	76 10	77 8½	68 4	78 8
1901	60 2	59 0	57 9½	57 6½	57 8	57 4½	57 8	61 0	60 0½	59 9	58 7½	56 7	58 7½
1902	56 1	57 9½	59 3½	59 9	59 10½	60 0	60 0	60 8½	61 5	61 2	59 3	59 0	59 6
1903	58 5	58 8	61 1	59 5	57 10	57 3	56 7	56 3	55 9	54 8	52 4	52 4	56 8½
1904	52 8½	53 1	53 7	54 9	54 2	53 2½	52 9	52 5	52 2½	52 7	53 1	55 11½	53 5½
1905	57 9½	56 9	58 1	58 2	56 4	55 8	55 5½	56 7	61 0	68 9	69 9	70 11½	60 5½
1906	70 4½	65 2½	63 4½	63 9	64 5	64 6	64 1	66 2½	67 3	69 4½	72 4½	78 8½	67 5
1907	77 9	72 11	71 10	73 9	79 9½	76 9	77 9	78 4	75 11	72 9½	68 6	66 7	74 4
1908	62 7	59 1	61 6½	61 6½	61 4	59 1	57 9½	56 11	60 2	59 2	58 5½	57 7	59 7½
1909	51 4	56 5	55 3	56 1	56 4	57 0	56 8	58 0	61 0	61 1½	60 7½	61 4	58 1½
1910	64 0½	64 3½	66 10½	67 6½	66 2½	65 4	64 4½	65 6½	65 2	64 10½	64 6	65 6	65 4½
1911	66 9	66 1	64 10	63 1	62 1	62 0	61 2	62 2	62 1	61 1	61 10	64 0	63 1
1912	67 0	67 0	67 0	69 3	71 0½	72 11	75 9½	79 1½	82 2½	85 0	85 3½	86 6	75 9½
1913	86 6	86 6	86 3	85 0	83 6½	80 10½	78 1	76 10½	72 6	71 0	68 0	65 3	78 4½
1914	64 6	65 4½	65 6	64 11½	64 2½	64 0	64 0	68 11½	74 6½	71 0	65 4½	69 9½	66 10½
1915	78 9	100 6	103 1	113 6	111 9	114 0	116 3	115 2½	113 8½	121 1½	131 9½	139 6½	113 3
1916	135 0	135 0	133 4	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6
1917	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6
1918	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6	127 6
1919	127 6	127 6	127 6	127 6	180 6	184 3	195 4½	204 6	204 6	204 6	204 6	204 6	174 7
1920	224 9	235 0	245 0	275 0	290 0	295 0	295 0	295 0	295 0	295 0	295 0	280 0	284 11½
1921	263 4	228 4	180 0	180 0	180 0	160 0	160 0	157 6	142 0	128 6	121 0	115 6	167 9½
1922	125 0	117 6	115 0	115 0	115 0	115 0	113 1½	104 0	105 0	105 0	106 3	110 0	112 1½

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